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JOURNAL *of the* BOSTON SOCIETY OF CIVIL ENGINEERS

111 YEARS
1848-1959

JULY - 1959

VOLUME 46 NUMBER 3

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Journal of Boston Society of Civil Engineers is indexed regularly by Engineering Index, Inc.

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Second-Class postage paid at Boston, Mass.

Published four times a year, January, April, July and October, by the Society
20 Pemberton Square, Boston, Massachusetts

Subscription Price $6.00 a Year (4 Copies)
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HYDRAULICS BY *ANALOG*

A Three-Part Series on the Use of Electronic Models in Hydraulic Engineering

PART 1. AN ELECTRONIC MODEL OF A PUMPING PLANT

By Henry M. Paynter,* *Member*

PREFATORY REMARKS

On November 5, 1958, a combined meeting of the Hydraulic Section and the Sanitary Section of the BSCE was held at the American Center for Analog Computing in Boston. A demonstration was given of the applications of high speed electronic models to the design and operation of engineering works related to storm drainage and sewage disposal problems in Metropolitan Boston.

This paper serves as the introductory part of the three-part series on this general subject. The latter two parts are intended for future issues of this Journal.

Here we treat very briefly and somewhat dogmatically the case of a pumping plant of a fairly common type. Only the most salient steps are indicated, leading to the direct establishment of an operating model, comprised of standard commercially available computing components. However, once interconnected, such an electronic model can serve for many design and operating studies. When these are completed, the parts are totally "salvageable" and available for other uses.

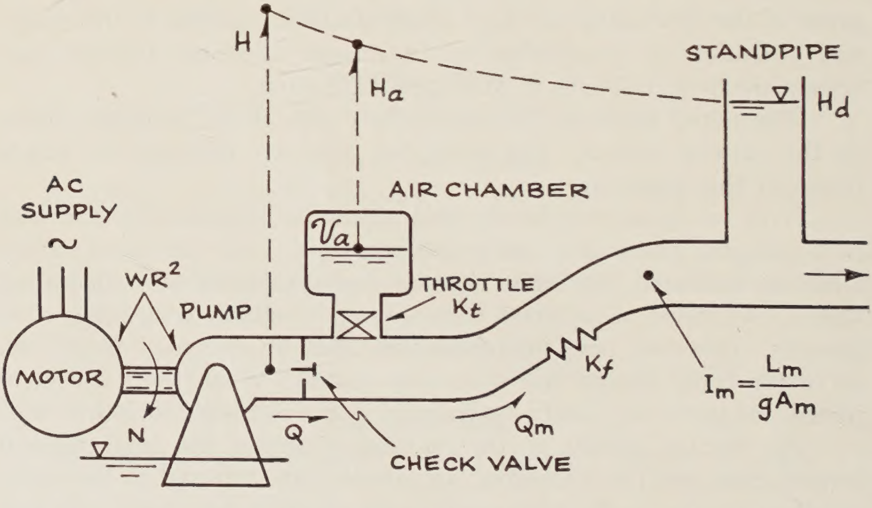
For further details of the physical situation, the mathematical formulation, and the computing art, readers are referred to the many excellent existing books and papers, some of which have been indicated in the short Bibliography at the end of this paper. We shall assume here that the mathematical formulation is correct, and will be concerned only with the steps necessary to make useful computer model studies. This particular problem was chosen primarily to demonstrate the benefits of modern machine computing but otherwise represents excessive over-simplification employed only for the sake of brevity; from the versatility and generality of the methods used, the extensions to actual cases should be apparent.

---

* Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology and Director, American Center for Analog Computing.

THE PHYSICAL SITUATION

Figure 1 depicts a commonly recurring type of centrifugal pump installation, supplying a standpipe with water, or other liquid, through a conduit, pipe, or force main. Typically, as shown, it might be equipped with a throttled air chamber to protect the discharge main from excessive pressure fluctuations, especially in the event of power interruption to the motor during operation and subsequent closure of the check valve. If there were no check-valve, the flow would reverse through the pump, ultimately reversing rotation and causing the pump to run as a turbine. Under such condition, the large reverse flow might flood the suction well and, in any event, would tend to drain the standpipe and other parts of the connected system.



PUMP INSTALLATION
FIG. 1.

Typical engineering studies are those concerned with effects on transient pressures in the discharge main of the following physical constants, among others:

(a) Check valve characteristics
(b) Air Storage: V_a
(c) Throttling loss: K_t
(d) Flywheel effect: WR^2

In particular, such investigations (which, of course, correspond to those made conventionally by graphical or numerical methods) are used to determine the economic size of the control features, such as the air storage and the flywheel effect, and the design values of such items as the throttling constant and check-valve parameters.

Table I outlines the physical situation in terms of the interrelationships between essential components and variables. In the computer model to be derived we are able to measure the values of these variables from instant to instant and are therefore able to study both transient and equilibrium conditions, for design and operating decisions.

TABLE I—COMPONENTS AND VARIABLES

ELECTRIC SYSTEM
AC Voltage (volts) : E_1 ↓ | ↑ I_1 : AC Current (amps)
INDUCTION MOTOR
Motor Torque (lb. ft.) : M_2 ↓ | ↑ N_2 : Motor Speed (rpm)
MECHANICAL INERTIA
Pump Torque (lb. ft.) : M_3 ↑ | ↓ N_3 : Pump Speed (rpm)
CENTRIFUGAL PUMP
Pump Head (ft.) : H_4 ↓ | ↑ Q_4 : Pump Discharge (cfs)
CHECK VALVE
Head Below Chamber (ft.) : H_5 ↑ | ↓ Q_5 : Check Valve Flow (cfs)
AIR CHAMBER
Upstream Head (ft.) : H_6 ↓ | ↑ Q_6 : Upstream Flow (cfs)
FLUID INERTIA
Gradient Head (ft.) : H_7 ↑ | ↓ Q_7 : Force Main Flow (cfs)
FLUID RESISTANCE
Standpipe Level (ft.) : H_8 ↑ | ↓ Q_8 : Downstream Flow (cfs)
STANDPIPE

The paragraphs below treat each of the components indicated and demonstrate how the basic relations can be used to establish a part-for-part electronic model. The computing components actually employed are described in Appendix A.

INDUCTION MOTOR CHARACTERISTICS

INPUT SIGNALS: Voltage E_1 and Speed N_2

OUTPUT SIGNALS: Current I_1 and Torque M_2

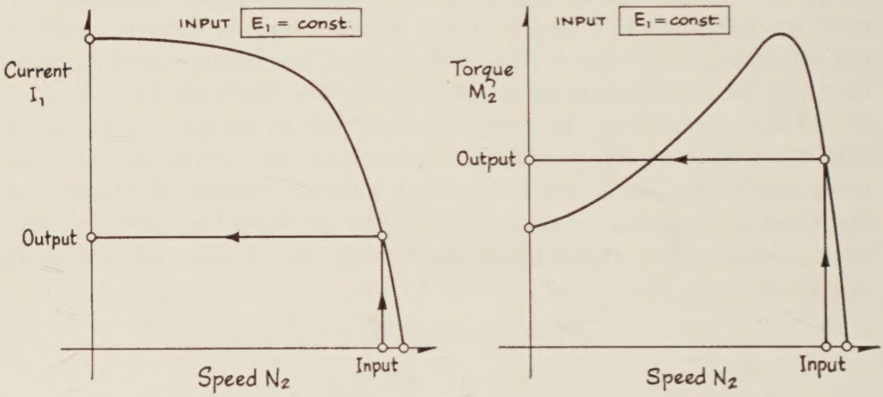


FIG. 2.

The standard characteristics for a 60 cps, three-phase, squirrel-cage induction motor have the form indicated in Figure 2. For computing purposes, such characteristics may be generated very easily through a direct representation of the simplified equivalent circuit portrayed in Figure 3. The corresponding equations can be written:

$$L \cdot \frac{dI_1}{dt} = E_1 - E$$

L = Motor Inductance

= Reactance/2π (Frequency)

$$E = [RN_s]\ I_1/(N_s - N_2)$$

R = Motor Resistance

$$M_2 = \left[\frac{30}{\pi N_s}\right] \cdot E \cdot I_1$$

N_s = Synchronous Speed

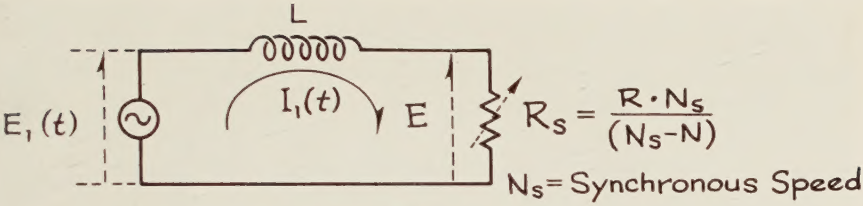


FIG. 3.

These equations may be directly instrumented in terms of the four basic computing components described in Appendix A. The resulting electronic model is given in block diagram form in Figure 4.

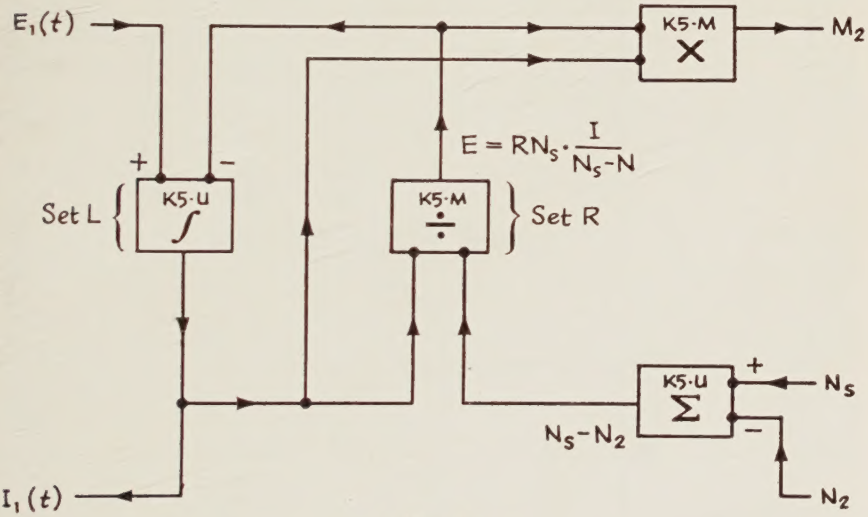


FIG. 4.

Actual measured characteristics for the computer model are indicated in Figure 5. These can be brought into conformity with any particular motor either by calculation of the motor constants R, L, and N_s, or by direct manipulation of the corresponding constants in the model.

FLYWHEEL EFFECT

INPUT SIGNALS:	Motor Torque M_2	and Pump Torque M_3
OUTPUT SIGNALS:	Motor Speed N_2	and Pump Speed N_3

This physical element manifests the effects of the rotary inertia

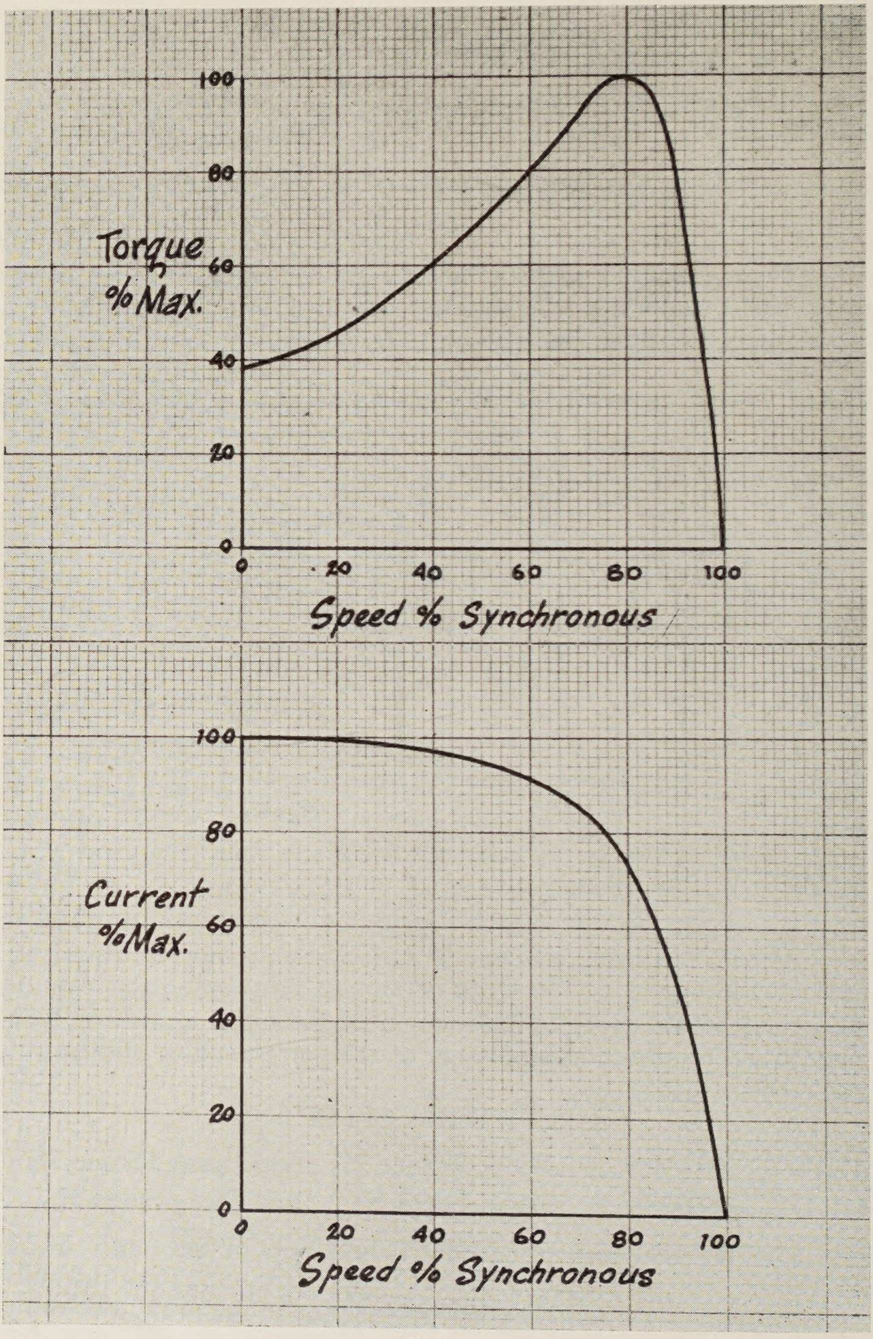

Torque % Max.
100
80
60
40
20
0
0
20
40
60
80
100
Speed % Synchronous
Current % Max.
100
80
60
40
20
0
0
20
40
60
80
100
Speed % Synchronous

Fig. 5.

of both motor rotor and pump impeller, together with the interconnecting shaft and any gearing. This involves the dynamical relation between speed variation (or acceleration) and the net accelerating torque, in the form:

$$\left[\frac{\pi WR^2}{30g}\right]\cdot\frac{dN}{dt} = M_2 - M_3$$

where $N = N_2 = N_3$ = Shaft Speed (in rpm)

WR^2 = Flywheel Effect (in lb ft^2)

g = Gravitational Acceleration (in ft/sec^2)

This relationship is instrumented by a single K5-U element used as a temporal integrator, as depicted in Figure 6.

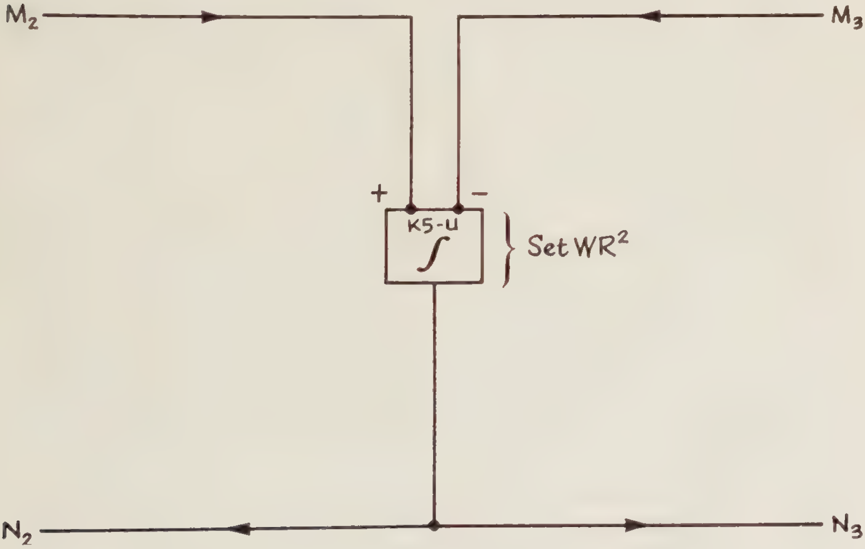


FIG. 6.

CENTRIFUGAL PUMP CHARACTERISTICS

INPUT SIGNALS: Pump Speed N_3 and Pump Flow Q_4

OUTPUT SIGNALS: Pump Torque M_3 and Pump Head H_4

The conventional characteristics of a typical medium head centrifugal pump would appear as sketched in Figure 7. Here, the variables N_3 and Q_4 serve as the inputs to produce as outputs, M_3 and H_4, as indicated.

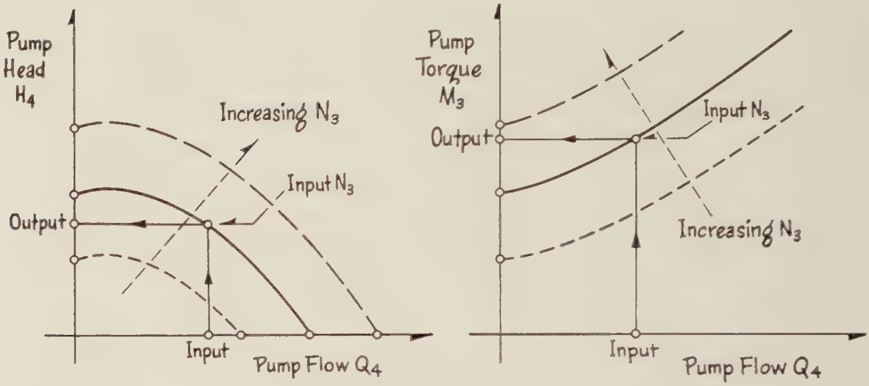


Fig. 7.

A very useful and practical approximation can be made to the characteristics of any fluid machine which is assumed to obey Euler similitude laws as the speed is varied. This representation can be expressed by the equations:

HEAD: $H = N\,(aN + bQ) - cQ^2$

TORQUE: $M = \left[\dfrac{\pi}{30w}\right] Q\,(aN + bQ) + dN^2$

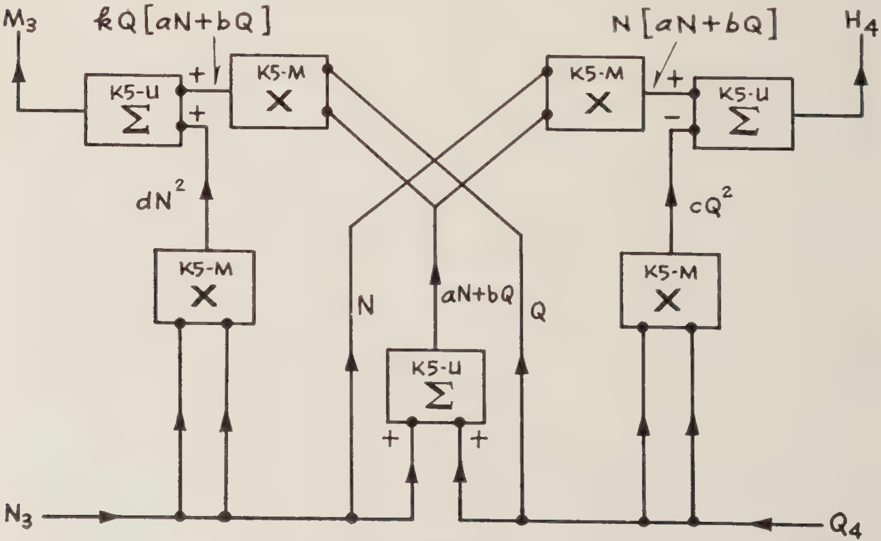


Fig. 8.

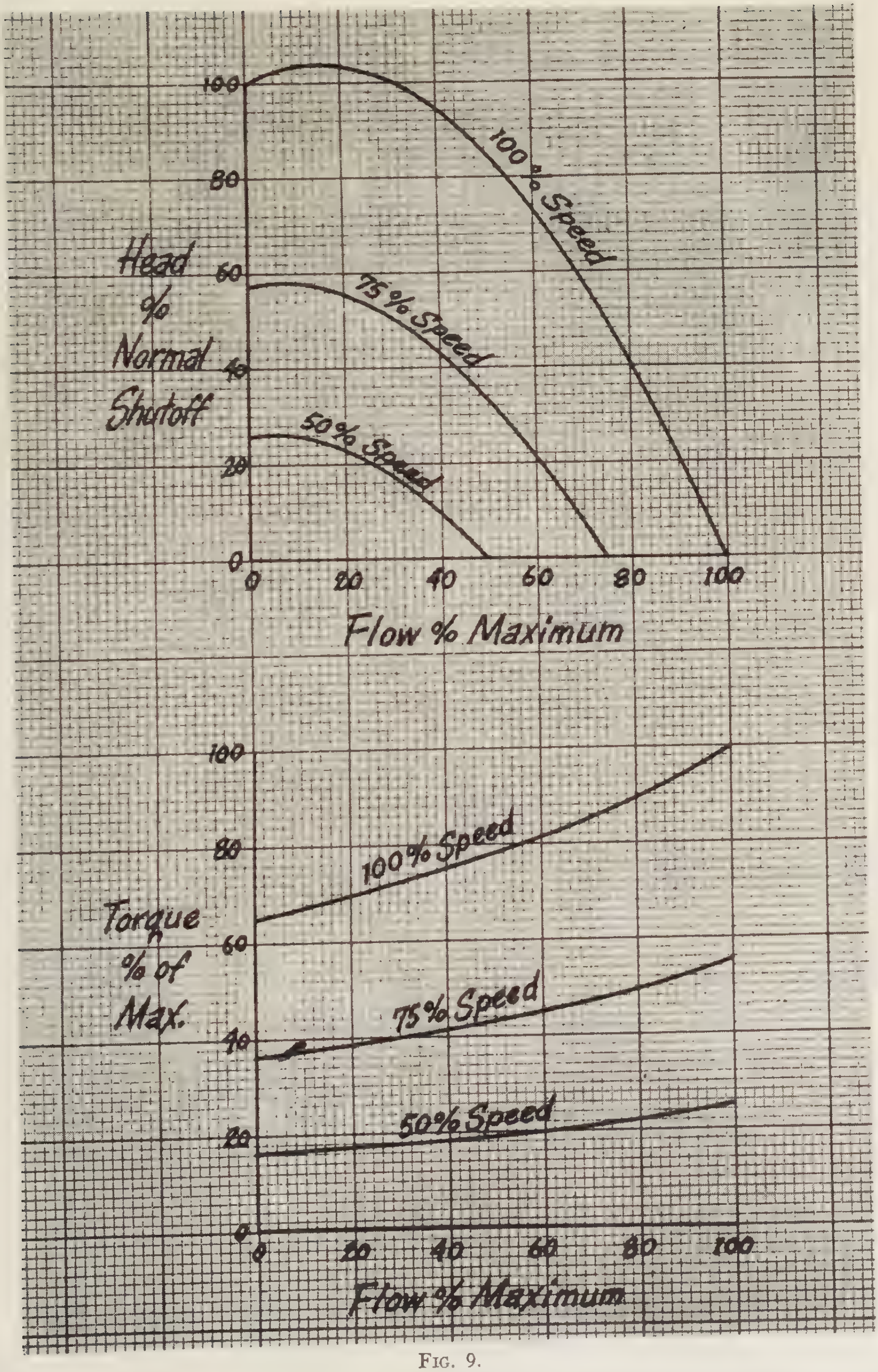

Head
% Normal Shutoff
100
80
60
40
20
0
100 % Speed
75 % Speed
50 % Speed
0
20
40
60
80
100
Flow % Maximum
Torque % of Max.
100
80
60
40
20
0
100% Speed
75% Speed
50% Speed
0
20
40
60
80
100
Flow % Maximum

FIG. 9.

where w is the fluid specific weight (lb/ft^3), and the constants a, b, c, d, depend on the particular type of pump. While these numbers generally can be related to the pump specific speed it is simplest to determine them by experimentation for each particular case.

Here, the term NQ (aN + bQ) represents the *whirl power* or reversible conversion: fluid energy ⇌ mechanical energy. The terms on the extreme right of each equation represent fluid and mechanical losses respectively.

The execution, of these relations, in terms of the two components K5-U and K5-M described in Appendix A, is indicated in Figure 8. Actual computed characteristics are indicated in Figure 9, for speeds 100%, 75%, and 50% of motor synchronous speed. The reduced speed characteristics are, of course, of extreme importance during normal start-up and shut-down as well as for power failure studies.

Most such pumps are equipped with a manual or motor operated discharge valve. The throttling action of such a valve can be included very simply in the value of c in the above relations.

CHECK VALVE CHARACTERISTICS

INPUT SIGNALS: Pump Head H_4 and Chamber Head H_5
OUTPUT SIGNALS: Pump Flow Q_4 = Valve Flow Q_5

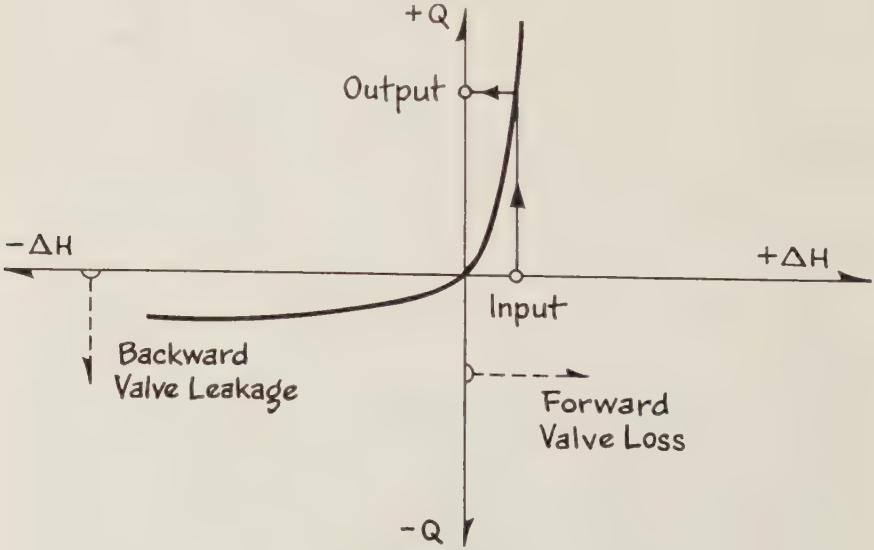


Fig. 10.

The check valve is provided to prevent reverse flow through the pump during an emergency loss of power. Typically, a swing-check would be used in such an installation, having a head-flow characteristic as depicted in Figure 10.

For most design and operating purposes, the detailed characteristics are not so important as the ascertainment of the head loss which can be tolerated for forward flow, when the check is opened, and the leakage reverse flow permissible under closed conditions. Thus a simplification in modeling is justified, which results in the block diagram of Figure 11 and the computed characteristics of Figure 12.

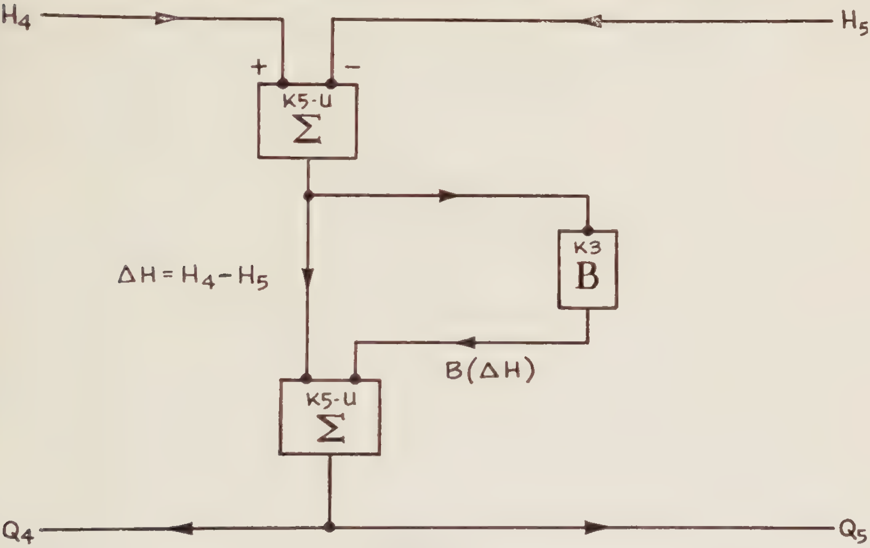


FIG. 11.

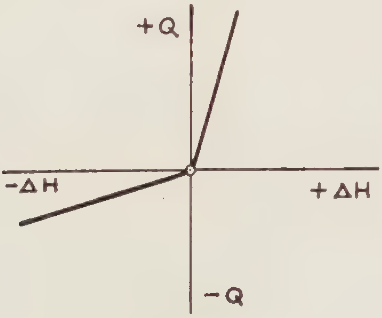


FIG. 12.

Here, the loss characteristic is represented as two straight lines, with vertex at the origin: $\Delta H = 0, Q = 0$.

AIR CHAMBER CHARACTERISTICS:

INPUT SIGNALS: Check Valve Flow Q_5 and Upstream Flow Q_6
OUTPUT SIGNALS: Chamber Head H_5 = Upstream Head H_6

The relationships governing the behavior of a throttled air chamber are determined in terms of the variables and parameters indicated in Figure 13.

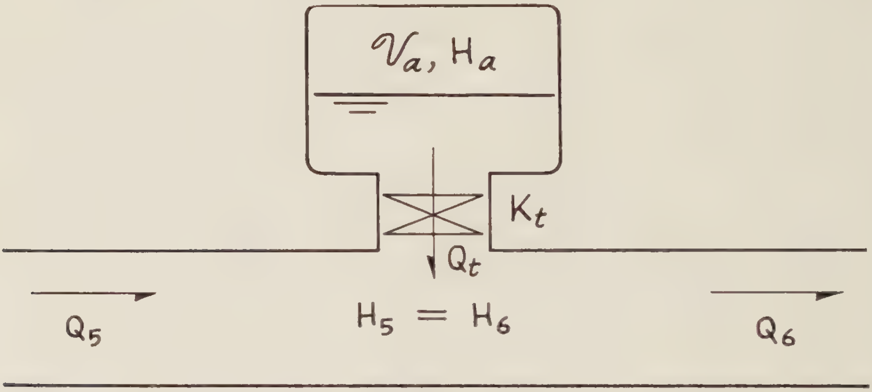


FIG. 13.

Thus the performance of any such system may be closely predicted in terms of the relations:

CHAMBER OUTFLOW: $Q_t = Q_6 - Q_5$
AIR VOLUME: $V_a = V_o + \int^t Qt\, dt$
AIR PRESSURE HEAD: $H_a = [H_o V_o]/V_a$
CHAMBER HEAD: $H = H_a - K_t |Q_t| Q_t = H_5 = H_6$

where V_o = Steady State Air Volume (in ft^3)
H_o = Corresponding Pressure Head (in ft)
V_a = Instantaneous Air Volume (in ft^3)
H_a = Corresponding Pressure Head (in ft)
K_t = Throttling Loss Factor (in ft/cfs^2)

Again these relations are simply and directly realized in terms of the three basic units (K3-V, K5-M, K5-U) indicated in Figure 14.

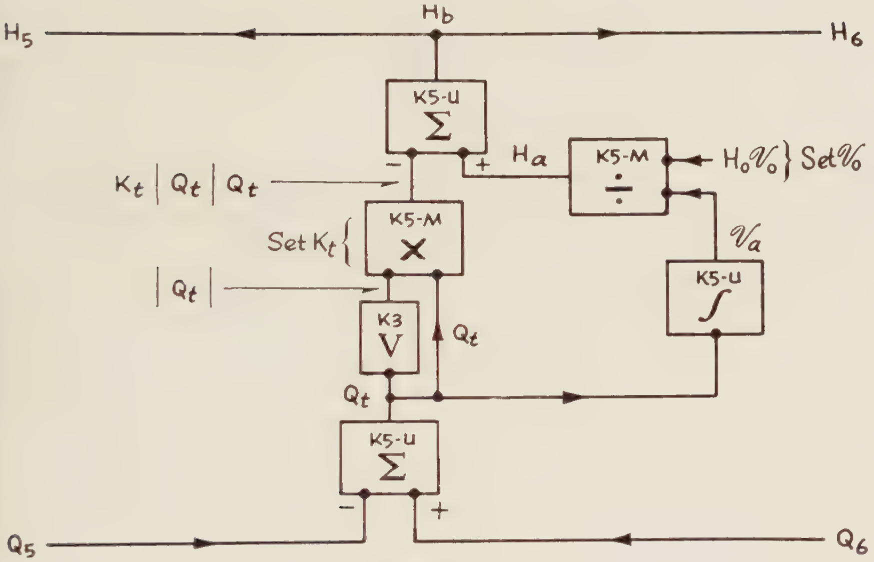


FIG. 14.

Note that incorporation of the loss characteristic permits the exploration of various throttle sizes (i.e. values of K_t) and their effects on performance. Similarly the size of the air chamber may be varied by altering the value of V_0.

FLUID INERTIA CHARACTERISTICS

INPUT SIGNALS: Upstream Head H_6 and Gradient Head H_7
OUTPUT SIGNALS: Upstream Flow Q_6 = Main Flow Q_7

If the compressibility of the water in the discharge main is neglected, which is a reasonable assumption for the present situation, with an air chamber at one end and a standpipe at the other end, the acceleration of the mass of water in the force main demands that:

$$\left[\frac{L_m}{gA_m}\right] \cdot \frac{dQ_m}{dt} = H_6 - H_7$$

where: Q_m = $Q_6 = Q_7$ = Flow in the Main (cfs)
L_m = Equivalent Developed Length of the Main (ft)
A_m = Equivalent Cross-Sectional Area of the Main (ft^2)
g = Gravitational Acceleration (ft/sec^2)

For the general case of a nonuniform pipe, the inertial factor, L_m/A_m, is given by:

$$L_m/A_m = \int_0^L ds/A(s)$$

This fluid inertia effect may then be included merely by realizing the above relationship in terms of a single K5-U operator as indicated in Figure 15. The value of L_m/A_m for any installation is altered by decade switch settings.

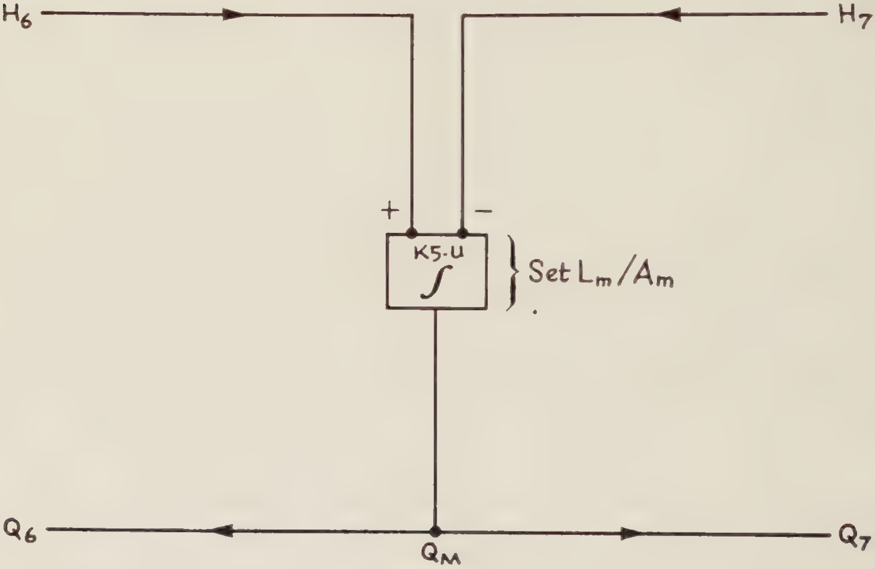


Fig. 15.

FLUID RESISTANCE CHARACTERISTICS

INPUTS: Pipe Discharge Q_7 and Standpipe Level H_8

OUTPUTS: Gradient Head H_7 and Pipe Discharge Q_8

This element represents all the pipe friction in the discharge main. The output flow Q_8 is, of course, the same as the input flow Q_7. If we can assume fully turbulent flow in a relatively rough pipe, then the head loss across the entire length of pipe is given by:

$$H_7 = H_8 + K_f|Q_7|Q_7$$

where the resistance coefficient K_f can be defined by the expression:

$$K_f = \frac{1}{2g} \cdot \frac{fL_m}{D_m A_m^2}$$

f = Pipe Darcy Friction Factor
D_m = Equivalent Pipe Diameter
and A_m, L_m, and g are as defined previously.

The value of K_f can be determined either by calculation or by observation for any pipe or composite series of pipes.

The corresponding block diagram for this element is indicated in Figure 16 with its performance as indicated in Figure 17. For those

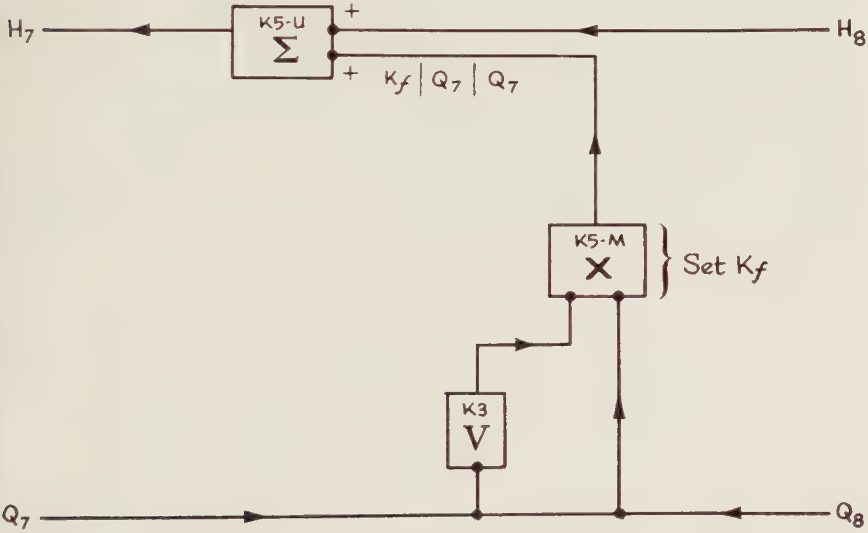


FIG. 16.

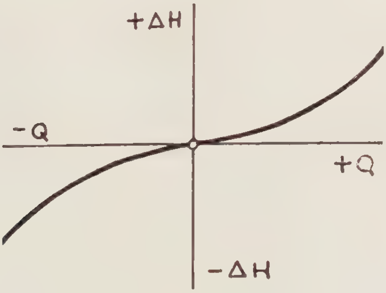


FIG. 17.

systems in which the forward loss constant K_f^+, is not the same as the backward loss constant K_f^-, it is possible to represent this effect simply and directly on the model.

FINAL COMPUTER MODEL

These performance relationships are programmed for solution by electronic computer following the block diagrams indicated in Figure 18. All the variables in such a computer representation correspond to actual plant variables and when the computer is properly interconnected it becomes, in effect, a flexible working model of the system.

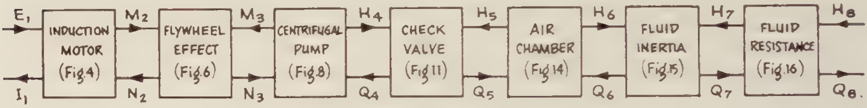


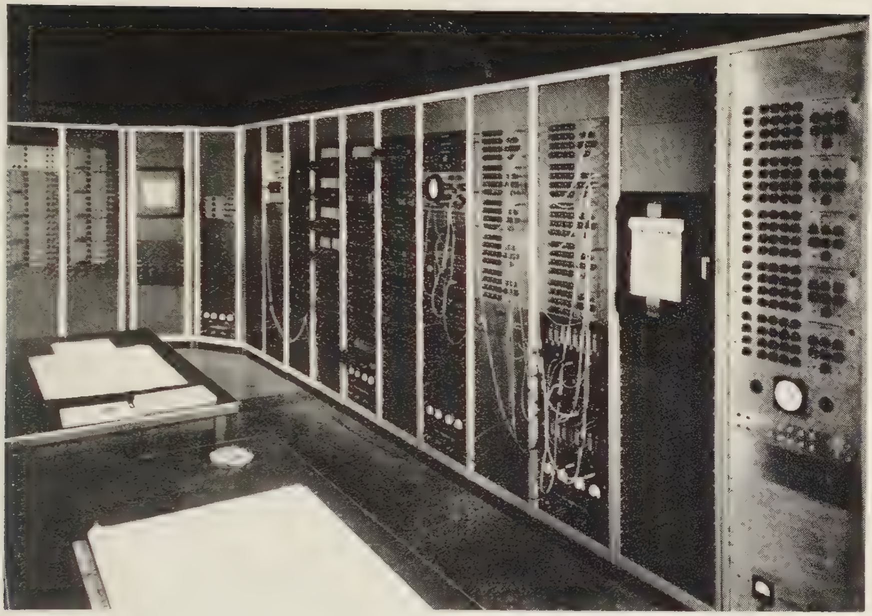
Fig. 18.

It is flexible in the sense that every physical characteristic in the actual system corresponds to an adjustable constant in the computer setup so that changes in design or in operating conditions can be explored fully. It is a working model because it reproduces both transient and steady-state phenomena present in the actual setup but frequently to different scales and of course in a different medium. For engineering studies of this sort, such an electronic model has many advantages, both for design studies and for simulated operating experience. When the particular studies are complete, such models can be disassembled, with complete and total salvageability. The next instalments in this series will indicate these advantages in more detail.

APPENDIX A

GENERAL NATURE OF ANALOG COMPONENTS

Recent advances in nuclear science, space travel, and automation testify dramatically to the value of computers in analysis, design, and development. The two major categories of computers are digital and analog. The first deals in numbers only; the latter, in continuous physical variables. In electronic analog computers, voltages are set up in direct correspondence with the pertinent physical quantities (such as speed, pressure, flow) of the problem to be solved. These voltages, the computer variables, are forced by obey relationships



closely approximating those of the problem to be solved. Time is generally the independent variable. The electronic components which establish the required relationships are principally amplifiers, potentiometers, resistors, diodes, and capacitors. However, those circuit elements are now commercially packaged so that no knowledge of electronics is required for successful use.

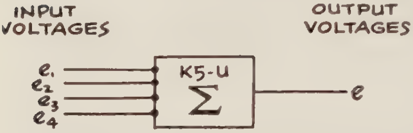
Such standard computing components form the major part of the equipment installed at AC AC, the American Center for Analog Computing, which is a division of George A. Philbrick Researches, Inc. located in Boston.

The staff and equipment at this Center have enjoyed considerable experience in the application of these arts to a wide variety of physical, chemical, biological, economic, and engineering systems.

SUMMATION AND INTEGRATION

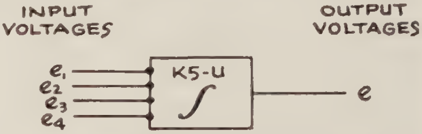
In this paper, these two operations are indicated by the blocks:

For Summation (Σ)



$$e = E + 10^{m}(a_1e_1 + a_2e_2 + a_3e_3 + a_4e_4)$$

For Integration ($\int$)



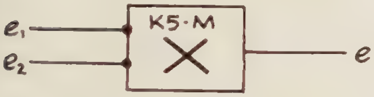
$$e = E + 10^{m}\int^{t}(a_1e_1 + a_2e_2 + a_3e_3 + a_4e_4)\,dt$$

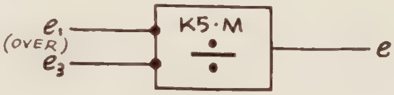
Both of these operations are embodied in the standard Philbrick Model K5-U Universal Linear Operator illustrated:

This unit combines inverting, proportioning, summing and integrating in a natural mathematical fashion. It provides set-run-hold conditions via perpetually reliable mercury relays. A combination of amplifiers maintain accuracy and stability, while coefficients and modes of operation are established by means of easily-set and easily-read decade switches.

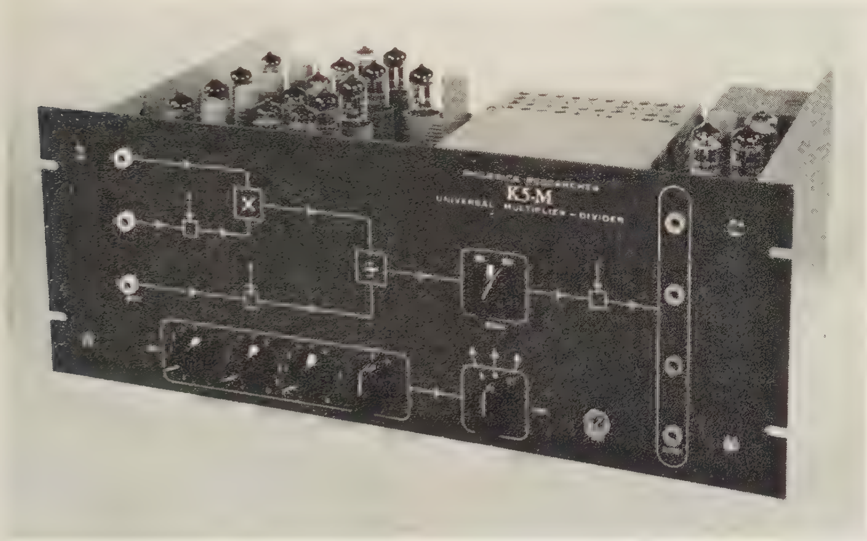
MULTIPLICATION AND DIVISION

In this paper, these two operations are indicated by the blocks:





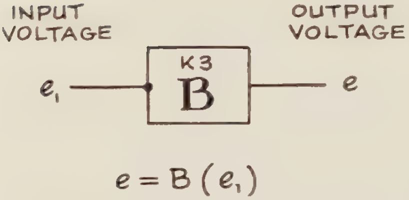
Both of these operations are embodied in the standard Philbrick Model K5-M Universal Multiplier-Divider illustrated:

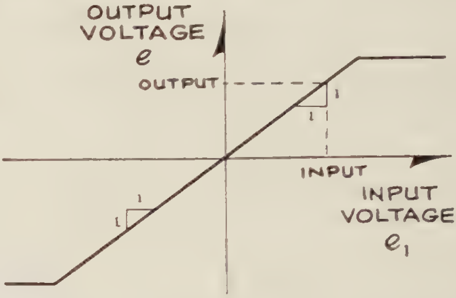


This component, in its most general usage, computes the product of two input voltages divided by a third. A constant voltage, adjusted by a triplet of decade switches, is additive to either type of input or to the output. Special cases taken in stride are the operations of squaring, reciprocating, and the evaluation of ratios and square roots. Accuracy, long-term, is of the order of 0.1%.

BOUNDING OR LIMITING

In this paper, this operation is indicated by the block:



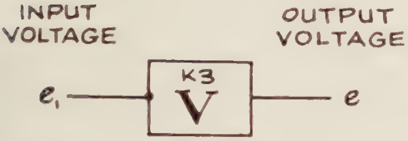


This operation is embodied in the standard Philbrick Model K3-B Bounding Component illustrated:

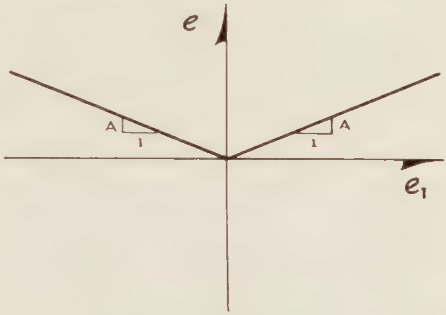
The output voltage from the K3-B is a limited version of the input voltage, in which the Positive and Negative bounds are individually adjustable. Each bound may be set linearly from zero up to a maximum of 50 volts. Except for being bounded, the output voltage follows the input and is not otherwise transformed.

ABSOLUTE VALUE OR RECTIFICATION

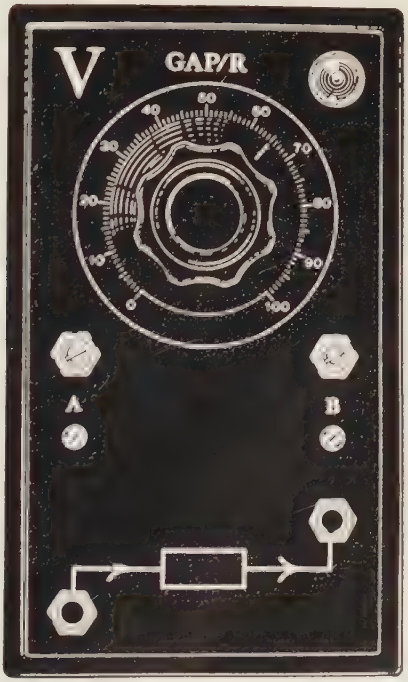
In this paper, these two operations are indicated by the block:



$$e = A\,|\,e_1\,|$$



This operation is embodied in the Philbrick Model K3-V Absolute Value Component illustrated.



The K3-V Component, often called simply the "Vee," computes instantaneously the absolute value of the input. Adjustment of the 0-100 front dial varies the numerical scale factor A from zero to unity. The "full-wave rectifying" action of this unit has a number of applications in dynamics and controls.

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DRAFT FOR THE PROPOSED AMENDED PART 23 LIVE AND DEAD LOADS OF THE BOSTON BUILDING CODE

By Frank H. Whelan

At the request of Mayor Hynes and under the sponsorship of the Building Commissioner, a meeting was held on December 11, 1958 at the City of Boston Building Department to organize a committee to draft a revision of Part 23 of the Boston Building Code. The members of the Committee are Frank H. Whelan, Chairman, Lawrence Burke, Vice-Chairman, Professor John M. Biggs, Miles N. Clair, Harry J. Keefe, William J. LeMessurier and David Mathoff, Secretary.

The separate sections of Part 23 were studied by the Committee and resulting recommendations were discussed, revised and approved, one by one, at the subsequent meetings.

On April 17, 1959, a copy of the final revision was distributed to several engineers for constructive criticism and on May 25, an open meeting of the Committee was held at Boston City Hall so all interested persons might give their views on the proposed revisions.

The final draft as presented here meets the approval of the Committee and will be submitted to the Building Commissioner for further action.

Part 23

Live and Dead Loads

Section

2301—Design for Loads.
2302—Dead and Live Loads.
2303—Weights of Materials.
2304—Loads from Partitions.
2305—Live Loads on Floors.
2306—Special Concentrations.
2307—Partial Loadings.
2308—Impact.
2309—Lateral and Uplift Forces.
2310—Reduction of Live Loads.

2311—Roof Loads.
2312—Wind Loads.
2313—Load Tests of Structure.

SECTION 2301 DESIGN FOR LOADS

All buildings and other structures and parts thereof shall be designed to support the loads and withstand the forces, to which they are subject; that is, live, dead and wind loads as required in this part without exceeding the stresses allowed elsewhere in this code for the various materials.

SECTION 2302 DEAD AND LIVE LOADS

(a) The dead loads of a building shall include all the forces due to weight of the walls, permanent partitions, floors, roofs, framing and all other permanent stationary construction and fixed service equipment entering into and becoming part of the building.

(b) The live loads shall include all loads other than dead load.

SECTION 2303 WEIGHTS OF MATERIALS

(a) The actual weights of the elements of construction and of materials to be supported shall be used in calculation of loads. The materials listed in the following table, in the absence of other data, shall be assumed to weigh not less than there indicated:

	Pounds per Cubic Foot
Brick (face, clay, shale or concrete) masonry	140
Brick (common) masonry	120
Cast iron	450
Cast stone masonry	144
Brick (sand, lime)	113
Gypsum	37
Cinders, dry, in bulk	45
Cinder fill	60
Clay tile masonry	54
Sand-cinder concrete, fill	100
Glass block masonry	54
Sand-cinder concrete, structural	110
Stone or gravel concrete, plain	144
Stone or gravel concrete, reinforced	150
Common earth, dry and packed	100
Sand and gravel (compacted)	120
Granite masonry	165

Limestone masonry	160
Marble masonry	160
Sandstone masonry	144
Steel	490
Timber	40
Water (fresh)	62.4

	Pounds per Square Foot
Plaster on metal lath exclusive of furring	8
Roofing, tar and gravel	6

SECTION 2304 LOADS FROM PARTITIONS

(a) In buildings in which permanent partitions occur, their weight shall be counted as affecting the design of all supporting structural members, including columns and foundations, as part of the dead load; and in those portions of buildings used for office occupancy, in which the prescribed live load does not exceed fifty pounds per square foot, allowance for partition weight shall always be made, whether or not partitions are shown on plans.

(b) If a lay-out of partitions is included in the building plans, the weights of the partitions and their locations shall be determined in accordance therewith, or such lay-out may be used to determine an equivalent load per square foot of floor to be applied uniformly as a super-imposed dead load for purposes of design. But the allowance for partition weight in portions of buildings given to office occupancy when expressed in pounds per square foot of floor, shall in no case be less than a minimum of two pounds for each foot of story height for each square foot of floor.

(c) In estimating loading from actual weights of partitions, it may be assumed that the partition occupies a space one foot wide, and a deduction may be made of the live load displaced on this width.

(d) Arch action of partitions shall not be assumed to relieve the supporting members.

SECTION 2305 LIVE LOADS ON FLOORS

The live loads assumed on floors for purposes of design shall be the greatest loads that will probably be produced, by the intended occupancies, but the following distributed live loads, in pounds per square foot, shall be taken as the minimum for the occupancies named.

For occupancies not listed, the design engineer shall submit in writing the proposed design live load to the Building Commissioner for approval.

	Pounds per Square Foot
Domestic Occupancy: all parts of private dwellings, rooms and suites in apartment houses, lodging houses and clubs; private, ward or dormitory rooms in hospitals, asylums, educational and religious institutions, including corridors giving access thereto; and bedrooms of hotels	40
Office Buildings:	
Basement	100
First Floor	80
Upper Floors	50*
Church Auditoriums: with fixed seats, including aisles, sanctuary or chancel, sacristies, choirs and chapels	60
Class Rooms: not exceeding nine hundred square feet in area, or larger size rooms where fixed seats are used	50
Kitchen, other than domestic, and school laboratories	100
Theatre Auditorium and Assembly Halls:† with fixed seats, including aisles and passageways	75
Theatre Stages: gridirons and fly galleries	150
Public Occupancy: lobbies, foyers, vestibules and similar public spaces of hotels, theatres, churches, clubs, and public buildings; assembly halls, including class and lecture rooms exceeding nine hundred square feet in area, without fixed seats; dance halls, public dining rooms and restaurants, public rooms for social purposes, skating rinks, gymnasiums	100
Bleachers:	
Grandstands and temporary grandstands	150
Corridors:	
In theatres and serving assembly halls	100
In school buildings	75
Other corridors—same loading as heaviest occupancy to which they provide access.	
Fire escapes and exterior balconies: in theatres and serving assembly halls	100
In other buildings	75
Stairs:† same loading as heaviest occupancy to which they give access, but maximum required	100

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* See Section 2304.

† For special floor concentrations and lateral thrusts on stair and balcony rails, see Sections 2306 and 2309.

Stores:	
For light merchandise, first and basement floors	100
For light merchandise, above first floor, including mezzanine	75
For heavy merchandise, all floors	125
Storage:	
Light storage	125
Heavy storage	250
Manufacturing:	
Light manufacturing	75
Intermediate manufacturing	150
Heavy manufacturing	250
Locker Rooms	75
Garages:[†] including apparatus rooms of fire stations:	
Class A—Floors used for vehicles exceeding 20,000 lbs. in weight, including loads; and first or street floors of garages except those limited exclusively to passenger vehicles of not more than 9 persons capacity	250
Class B—Floors not included in Class A and first or street floors of garages limited to passenger vehicles exclusively weighing not more than 9,000 lbs.	150
Class C—Floors above the first or street floors for passenger vehicles weighing less than 6,000 lbs.	100

A floor connected directly with the street or by a ramp or driveway not more than eight feet high shall be regarded as a first or street floor.

Sidewalks[†]	250
Driveways[†]	250

All plans filed for permit shall include a list or notation of the live loads used in design.

SECTION 2306 SPECIAL CONCENTRATIONS

In the design of floors and structural systems, consideration shall be given to the effects of known or probable concentrations of load to which they are subjected; and in structures designed for the occupancies listed herein, floors shall be made capable of carrying the prescribed distributed loads or the following minimum concentrations, whichever may result in the greater stresses. The concentrations indicated shall be assumed to occupy two and one-half feet square, and be so placed as to produce maximum stresses in the members affected.

[†] For special floor concentrations and lateral thrusts on stair and balcony rails, see Sections 2306 and 2309.

(1) For office floors including corridors, theatre stages, gridirons and fly galleries and corridors serving them a load of two thousand pounds.

(2) For portions of garages subject to Class A loading, a concentrated load of twenty thousand pounds, and for Class B loading, ten thousand pounds.

(3) For sidewalks, a concentrated load of 12,000 pounds.

(4) For driveways, and for trucking spaces within the limits of a structure, a concentrated load of twenty thousand pounds.

(5) For structural supports of ceilings under accessible spaces, for trap doors and skylights a concentrated load of two hundred pounds.

(6) That portion of hangars subject to concentrated loads shall be designed to accommodate the heaviest vehicle housed therein.

(7) For elevator machine room grating (on an area of four square inches), a load of three hundred pounds.

(8) For stair treads (on center of tread), a load of three hundred pounds.

(9) For exposed metal light floor plate construction (on an area of one square inch), a load of two hundred pounds.

SECTION 2307 PARTIAL LOADINGS

(a) The effect of a partial live load on a structure taking into account its construction, connections, and rigidity, which will produce maximum stress in any member, shall be provided for in the design, as well as full live loading.

(b) The partial loading shall also conform to the design requirements of other sections of this code.

(c) For snow load requirements, see Section 2311.

SECTION 2308 IMPACT

The live loads prescribed herein may be assumed to include a sufficient allowance to cover the effects of ordinary impact. For special occupancies and loadings involving unusual impacts, such as those resulting from moving loads, machinery, elevators and craneways, provisions shall be made by suitably increasing the live load. In the case of machinery care shall be taken to avoid near resonant conditions.

SECTION 2309 LATERAL AND UPLIFT FORCES

(a) In the design of basement walls and similar approximately vertical structures below grade, the forces due to lateral pressure of adjacent soil shall be calculated. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or the whole of the adjacent soil is below a free water surface, calculations shall be based on the weight of the soil as diminished by buoyancy, plus full hydrostatic pressure.

(b) In the design of basement floors and similar approximately horizontal structures below grade, the upward pressure of water, if any, in the supporting soil, shall be taken as the full hydrostatic pressure applied over the entire area.

(c) Balcony and stairway railings, exterior and interior, shall be designed to resist a horizontal thrust of twenty pounds per linear foot applied at the top of the rail.

SECTION 2310 REDUCTION OF LIVE LOADS

(a) Roof Live Loads—No reduction shall be applied to the roof live load.

(b) Live Loads 100 Pounds per Square Foot or Less—For uniformly distributed live loads of 100 pounds or less per square foot, the design live load on any member (not including one-way slabs) supporting 150 square feet or more may be reduced at the rate of 0.06 percent per square foot of area supported by the member, except that no reduction shall be made for areas to be occupied as places of public assembly. The reduction shall exceed neither R as determined by the following formula, nor 50 per cent:

$$R = 100 \times \frac{D + L}{5L}$$

in which

R = reduction in percent
D = dead load per square foot of area supported by the member
L = design live load per square foot of area supported by the member.

(c) Live Loads Exceeding 100 Pounds per Square Foot—For live loads exceeding 100 pounds per square foot, no reduction shall be made, except that the design live loads on columns may be reduced by ½ the quantity specified in (b).

SECTION 2311 ROOF LOADS

(a) Flat roofs, and roofs having a rise of two inches or less per foot of run shall be designed to support a vertical snow load of thirty pounds per square foot of horizontal projection. Roofs used as roof gardens, or for other such purposes shall be designed as floors to support the load prescribed for corresponding occupancies.

(b) Roofs having a rise of more than two and less than twelve inches per foot of run shall be designed for a vertical snow load of (34-2r) pounds per square foot of horizontal projection in which r is the rise in inches per foot of run.

(c) Roofs having a rise of twelve inches or more per foot of run shall be designed for a vertical live load of ten pounds per square foot of horizontal projection.

(d) Roof structures or portions thereof shall be designed for stresses produced by partial snow loading whenever such stresses exceed those produced by full snow loading. In such cases the partial snow load may be assumed equal to two-thirds of the load required by paragraph a, b, or c of this section.

(e) All roofs shall be designed for the wind loads specified in Section 2312. Two-thirds of the wind load required by Section 2312 shall be combined with two-thirds of the snow load required by paragraph a, b, c or d of this section, whenever such a combination produces higher stresses than those existing with wind or snow load acting separately.

SECTION 2312 WIND LOADS

(a) All buildings shall be designed to resist wind forces applied to both walls and roofs without exceeding the stresses allowed in this act.

(b) The design wind pressure P in pounds per square foot shall vary with the height above the average ground elevation adjacent to the base of the structure in accordance with the following table: In the case of a sloping roof the height shall be the average height of the roof.

Height in Feet	P in Lbs. per Square Foot
0— 25	20
25— 50	25
50— 100	30
100— 150	35
150— 400	45
400— 700	55
700—1500	65

(c) Wind pressure on the elements of a building shall not be less than the following values:

Total horizontal pressure on the walls of rectangular buildings (combining the effect of pressure on the windward wall and suction on the leeward wall)	1.0 P
Total horizontal pressure acting simultaneously on each of any two perpendicular walls of a rectangular building (combining the effect of pressure on the windward walls and suction on the leeward walls)	.7 P
Pressure in or out on an exterior wall	1.0 P
** Total suction on the entire surface of all roofs	1.2 P
Pressure normal to windward surface only of roofs with slopes equal to or greater than 30 degrees (to be combined with zero pressure on leeward slope)	.9 P
Uplift on eaves, cornices or other local projections, and fastenings of roof coverings	1.5 P
Total pressure on gross area of signs with less than 25% openings	1.2 P
Total pressure on net area of signs with more than 25% openings	1.6 P
Total pressure on projected area of round chimneys or tanks	.7 P

(d) As an alternative to the provisions of Section 2312 (c) and with the approval of the Building Commissioner, wind force on a building may be based on shape coefficients obtained from wind tunnel tests of models or by other approved methods. Such shape coefficients shall include the full effect of openings in wall or roof surfaces. In such cases the velocity pressure "q" to be used at any height shall be taken as .77 P where P is given by the table in paragraph 2312 (b).

(e) Where dead load forces reduce the effect of wind loads, two-thirds of dead loads shall be used in calculating the net effect of wind. Roofs and walls shall be anchored against uplifting or overturning when such forces exceed two-thirds of counter-balancing dead load forces.

SECTION 2313 LOAD TESTS OF STRUCTURES

(a) The Commissioner shall have the right to order tests under load or other tests of any portion of a structure when the conditions have been such as to leave reasonable doubt as to the adequacy of the structure to serve the purpose for which it was intended. Such tests shall not be required to be made on any concrete or masonry construction until it is at least sixty days old.

** Resulting from wind parallel to the ridge in the case of gable roofs.

(b) In such tests, the member or portion of the structure under test shall be subjected to a total load, including its own weight, which shall equal the total dead load plus twice the live load for which it is required to be designed. This load shall be left in position for a period of twenty-four hours before removal. The structure, if a floor or portion thereof, shall be considered to have passed the test if within twenty-four hours after the removal of the load such floor or roof recovers three quarters of the maximum deflection under the test load. If the member or portion of the structure shows evident failure or fails to meet the recovery requirement, it shall be rebuilt or may be modified as is necessary to make the structure adequate for the rated capacity, except that, where lawful, and where the structure is undamaged, a lower rating may be established.

ENGINEERING FOR NATIONAL SECURITY

By Major General Emerson C. Itschner*

Read by Brigadier General Alden K. Sibley,** *Member*

(Presented at a joint meeting of the Boston Society of Civil Engineers and the Boston Post, Society of Military Engineers, held on January 21, 1959.)

The engineer has played a more significant role in national security and advancement in the United States than perhaps in any other nation. That has been due to the peculiar circumstances of our national origin and the availability of a large, rich frontier suddenly opened for development by an aggressive people who were ready for it.

The engineer was a key figure in winning our national independence. His skills hastened the settlement of the frontier. His work in constructing roads, canals, harbors, waterways and railroads made possible the economic integration of this vast land within a single century and helped to build our modern industrial society.

The engineer's role in defense from the earliest days to the present time has been equally fundamental and dynamic. In the United States, the engineering profession originated with military necessity and grew out of the establishment of the Army's Corps of Engineers and the U. S. Military Academy at West Point for the training of engineers and other military leaders. There has been a close community of interest between the military and the civil engineer from that period to our own time.

Thus, in addition to his modern technological skills, the American engineer has an excellent background of tradition for meeting the requirements of our present military and economic emergency. For the primary problems of national security today are basically military and economic, and the two are closely integrated.

Many people are so appalled by the prospects of nuclear war that they tend to overlook the risk that we could lose the world conflict by failure to counter Soviet efforts for economic penetration and political domination of the undecided nations outside the Iron Curtain. While we must be prepared to fight a hot war and marshal military strength to deter it, we are already fighting an economic and political war. To lose it would be as disastrous as to lose a military war.

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* Chief of Engineers, U.S. Army.

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Both types of conflict present new, difficult and important tasks for the engineer. Primary among these are the technological aspects of how to cope with two of the most formidable forces known. These have been loosed upon the world by Science opening the Pandora's box of technological advancement before we were morally and spiritually ready for it. They are:

> The inter-continental missile, with its nuclear blast that could devastate a nation in a single, concentrated attack, within a few minutes time; and
>
> The pressure of the world's explosive population growth on the limited natural resources of this already crowded planet.

Two recent events highlight the imminence of these threats as problems demanding immediate action:

In mid-December, the world's largest and best equipped missile facility was put in service at Vandenberg Air Force Base in California. Here men are being trained to fire the new inter-continental missile. Bases for actual deployment of the weapon are already under construction in the United States. The enemy too, has advanced far, and either has or soon will have the capability for sending nuclear destruction over the great Polar arc to destroy wide areas of our country. The problem of how to survive the availability of such a weapon is upon us.

Last November, Dr. Philip M. Hauser, Head of the University of Chicago's Population Research Center, announced that the United States may grow to as much as a billion people in less than a century, if current trends continue. He thinks we may number almost a quarter billion people just sixteen years from now.

Even though the growth may fall short of that predicted, it will certainly be extremely large. Moreover, it is part of a global trend. Great Britain's leading soil scientists a few weeks ago warned that the world would need to support six billion people in the next century. That is three times the present population.

This problem, too, will soon be upon us in full force. We see its advance effects in world-wide social, economic and political turbulence upon which the Soviets seek to capitalize. At home, we already feel the repercussions. And we are beginning to feel the pressure of our own population growth: in urban expansion, the overcrowding of our schools and thoroughfares, the increasing problems of water supply, flood protection, stream pollution and soil depletion, and in many other ways.

So, on the one hand, we must be prepared to fight an intercontinental nuclear war, if necessary, and to repel country-by-country "installment plan" aggression whether it be military, economic or political, or a combination thereof.

On the other hand, we must support the phenomenal growth of our own population, and help friendly or undecided nations to find ways to support theirs.

These tasks call upon us to exercise the utmost of engineering ingenuity in military advancement and in keeping our country strong and dynamic. They hold special significance for engineers of all kinds—military and civilian. For we must literally, as well as figuratively build our way to security, military and economic. All aspects of technological warfare and military construction to support it, as well as economic activity such as water resources development, the highway program, schools, housing, utilities, industrial expansion—all must move ahead—at an accelerating rate.

Scientists and engineers are in a very real sense ultimate weapons in our struggle for suvival in the nuclear age. Before the plans for a new weapon or a new piece of equipment are off the research and development drawing board, the construction engineer must plan its installation. Many of his designs will be unprecedented, requiring pattern-making engineering solutions, such as the Arctic airbases using ice and snow as materials; snow tunnels in lieu of roads on the ice cap, and for crack-proof rigid pavements to carry 240,000-pound gear loadings on frost-susceptible, glacial till material. The construction engineer is among the first to come to grips with realization of the national strategic concept. Construction capabilities frequently dictate the feasibility of military plans and operations. Meticulous design, careful supervision and inspection must produce the high standard of construction for which the Army Corps of Engineers is reputed.

Our revitalized military defense program is now and will continue to be costly. The Corps of Engineers is concerned, of course, with the military construction, combat engineering and other technological support aspects of the program. The Corps' military construction program in recent years has amounted to about \$1½ billion per year in Continental United States and overseas. Under our unified defense system, the Corps performs construction for the Army, Air Force, National Guard and some construction for the Navy.

The Air Force is our biggest client. Although most of the construction for the Air Force is still conventional, consisting of modification and expansion of existing facilities and bases, construction of missile installations is rapidly coming to the fore. This year missiles account for 15 percent of the Corps' military construction. In Fiscal Year 1959 however, we expect support of missiles to amount to about 40 percent of our military construction.

New England has a big stake in the military construction program. This strategic, northeast corner of the United States is now in the front lines of potential inter-continental warfare. The shortest air route from Moscow to Washington would pass over Maine, Vermont, New Hampshire, western Massachusetts and on to Washington. A Soviet jet bomber flying that route would be within 15 minutes of any New England city. An inter-continental missile could span the whole distance in little more than 30 minutes. Thus New England, by virtue of its geography, its industrial targets and population concentration, is indeed of critical strategic importance.

What does this mean to New England? The U. S. Army Engineer Division, New England, has constructed and is now adding to one of the most concentrated centers of defense in the nation. We have the multi-million-dollar Strategic Air Command bomber bases like Loring, Dow, Westover and Portsmouth. We have our warning facilities dotting the area and the Texas towers ever watchful off the coast. We have a complex system of aircraft control and warning, and we are now building inter-continental missile facilities at Presque Isle in Maine. We are building such weapons systems as these in strategic areas throughout the nation. With their development and the sure knowledge of their retaliatory capability comes one of our greatest deterrents to war and therefore one of our greaters powers for peace.

The industrial and air-base complexes of New England are now defended by the Army's NIKE AJAX missile batteries designed to spell the doom of the piloted bomber. These facilities are now being modified to accommodate the longer range NIKE HERCULES missiles. These deadly air-defense missiles are being supplemented in New England by the Air Force's BOMARC IM–99 missile, a long range ground-to-air interceptor missile designed to operate at high altitudes and supersonic speeds. Launched by a liquid-fuel rocket engine, the BOMARC is a weapon 47 feet long with a wing span of 18 feet. In Presque Isle, Maine, the first operational SNARK missile base in the United States is now under construction. This missile, not to be confused with a ballistic missile, is a surface-to-surface intercontinental cruise (subsonic) missile with a range of over 6,000 miles.

Besides construction, another missile responsibility held by the Corps is Engineer support for Army deployment of the weapon. The Redstone Missile, for example, which uses great quantities of liquid oxygen (called LOX) as a propellant, requires refrigeration at minus 296 degrees (F) in order to avoid excessive loss in storage and transportation. Already five and 20-ton transportable manufacturing plants have been developed for operation by Engineer troops close to launching sites, and a 50-ton plant is under development. Nine-ton tractor-trailer LOX units are being procured in New England to equip IRBM units deployed overseas.

In support of ground and airborne forces in the missile age, the Corps has devised airborne construction equipment, tank-mounted bridges, mechanical minelayers, jeep-mounted mine detectors, and tank-mounted mine-clearing devices that will help troops move more rapidly and fight more effectively. We have infra-red equipment to help them see at night. We are helping meet problems of supply to small, fast-moving groups. We can quickly provide large numbers of accurate maps, which contain more information about trafficability than ever before. Meanwhile we are cooperating with 63 other nations to establish a unified international mapping grid system for use in missile operations and strategic planning.

I have given you only the highlights of what engineering is contributing to military defense through the Corps of Engineers. And now, what are we doing about the second aspect of engineering for national security—the problem of population growth?

One of the most essential elements to a strong and growing economy, to support both military defense and national growth, is water resources development. The Corps of Engineers holds a large share of the national responsibility for this activity. We are pushing forward a nation-wide $800-million annual program of investigations, construction and operations of flood control, navigation, hydro-electric power, water conservation, and related activities. Our investigations and construction programs are proceeding on the basis that we shall ultimately need full use of our water resources to meet the seemingly insatiable demands being placed upon this vital resource. We shall need greater flood protection as the centers of production along our rivers expand. Our inland waterways have become virtually floating mass-production lines as heavy, bulk materials are carried from plant to plant in the various stages of processing. Barge traffic has about doubled over the past decade and will grow considerably. Our harbors are becoming increasingly important as we look more to the importation of essential raw materials.

Just three short years ago the flood control program in New England was given added impetus as the result of one of the worst floods in the history of the northeast. In an effort to prevent the recurrence of a similar major economic dislocation in one of the most highly industrialized areas of our country, the Corps of Engineers has made rapid progress in the construction of the New England flood control system. In fact, the progress we have made in the past three years in planning and constructing protective facilities in this area has been truly remarkable. I know of no other area in the country where so much has been accomplished in such a short time following a flood disaster.

Under this accelerated planning and construction program, seven new flood control projects have been completed at a cost of $10 million, 12 projects at a cost of $104 million are now under construction (many of which will be completed within a year) and six more projects aggregating about $11 million in cost are now being designed. This is a total of 25 flood control projects which will be completed soon at a total Federal cost of over $125 million.

The significance of this accomplishment is evident when we compare this three-year record with the total history of flood control construction in New England prior to August 1955. In the more than 30 years following the major flood of 1927, 23 flood control projects were built. This represents about 20 percent of the comprehensive program recommended by the Corps of Engineers and authorized by Congress before 1955. In other words, when our present program is completed, we will have done more to provide flood protection in the few years since the 1955 flood than was accomplished in the whole previous history of New England.

This is only part of the picture. With the aid of their Congressional delegations, the people of New England have gained a greatly augmented flood control program, in addition to the millions of dollars appropriated for projects already authorized. The Northeast Flood Studies and Hurricane Studies have thus far resulted in the authorization of two major hurricane protective works on Narragansett Bay and in New Bedford Harbor.

The task of engineering for national security demands that we preserve a sound and healthy domestic economy to support our military defense programs. We must not sacrifice one on the altar of the other. We must never lose sight of the fact that the Soviets have declared and are fighting the economic "cold" war. As Kruschev challenged: "We declare war upon you in the peaceful field of trade. We declare war. We will win over the United States. . . . We are relentless in this, and it will prove the superiority of our system."

To face this challenge with success, while at the same time deterring the Communist bloc from open military aggression, will require more than the taxpayer's dollar, more than national determination and fortitude. It will require national brains!

We must remain acutely conscious that the greatest power on earth is and always will be the human mind—the thoroughly trained and highly educated mind. The real war of today and tomorrow is the war of men's minds. We can no longer afford to rely upon the scientists of Europe to provide us with the basic scientific knowledge on which our great technology rests. As engineers we can help improve the lot of the small and devoted group of pure scientists in the United States by understanding them and applying the fruits of their basic research to technological development. The military engineer today can no more afford to ignore the methods and achievements of pure science than can the statesman ignore the intercontinental missile and the Pentomic Army.

We must feed our strong and virile technology with solid scientific nourishment, and the engineering profession must digest this nourishment and put it to use building national growth and strength as rapidly as it emerges from the laboratory. Herein lies our profession's great challenge.

SURVEYS IN CONNECTION WITH THE PREPARATION OF CONSTRUCTION PLANS FOR SEWERS IN DERRY, N. H.

By Harry R. Feldman,* *Member*

(Presented at a meeting of the Surveying and Mapping Section, B.S.C.E., held on January 28, 1959.)

Those of you who have driven through Derry, N. H. have done so perhaps by way of the Londonderry Turnpike (Bypass 28) and think of it as being simply a route junction with two service stations and an ice cream stand. The main portion of Derry is about one mile west of the above mentioned intersection, called West Derry, and is actually a picturesque modern community with a population of about 6,000. It has several successful industries among which is the original Harvey Perley Hood Milk Farm.

As in so many other similar towns, however, it had failed to develop a satisfactory sewage disposal system. The present Board of Selectmen realized the need for urgent action on this problem, "because of the increasing deterioration of Derry's water supply and the antiquated and unsanitary method of the town's sewage disposal system—" and engaged Camp, Dresser and McKee, consulting engineers, to propose and follow through a satisfactory solution.

After making sufficient preliminary studies, the consulting engineers engaged Harry R. Feldman, Inc. to make the surveys from which contract drawings could be made. It is with this phase that this paper is concerned.

The survey requirements were these:

(1) Plans of all streets to be drawn at a scale of 1″ = 40′ showing buildings, trees, utilities, travelled ways, and other pertinent topographic features.

(2) Profile data along all streets with sill elevations to 0.1′ or better.

(3) Topography of two cross-country strips (for interceptors) to be plotted at forty scale and with two-foot contours or better.

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* President, Harry R. Feldman, Inc., Boston, Mass.

(4) Research and field work in regard to land takings or easements.

From an existing small scale map of the town, it was estimated that there were about one hundred streets averaging 1,000 feet in length or approximately twenty miles of streets to be mapped. Also, through this area of about three square miles, were two brooks which met at a "Y" intersection in the south west part of the town close to the area of the proposed sewage stabilation ponds. It was felt that these brooks were suitably located and, with their natural gradients, would be ideal along which to place the trunk line interceptor sewers. These were the two cross-country strips to be surveyed as mentioned above and were each about 7,000 feet long.

Realizing the relative magnitude of the job, the question arose of how best to make the necessary surveys keeping in mind the usual parameters, for the least cost in the shortest time. Aerial methods were immediately considered. Although aerial photogrammetry is more than one hundred years old, it has only been in the past decade that it has made its greatest advances and then thought of mostly in terms of large highway projects. Then too, the elevation requirements were, for the most part, too fine for standard photogrammetric methods.

An estimate of time and cost, therefore, was made up in two ways:

(1) Complete conventional ground survey.

(2) An aerial survey for planimetric data with conventional methods for elevations. The results indicated that the combination aerial and ground method would be better in that the cost would be about 30% less and would take only half the time of the conventional method. Needless to say, the job was flown.

The U. S. G. S. "quad sheet" (Fig. 1) was delineated and the area flown by Lockwood, Kessler and Bartlett, Inc. in the early Spring before the foliage appeared. In the interim, surveys were started along the banks of the two brooks keeping in mind to have the survey lines as close as possible to satisfactory interceptor sewer locations.

The aerial photographs were delivered with requests to locate and coordinate 18 horizontal control points. Since there were no geodetic coordinated points in the area concerned, it was decided to

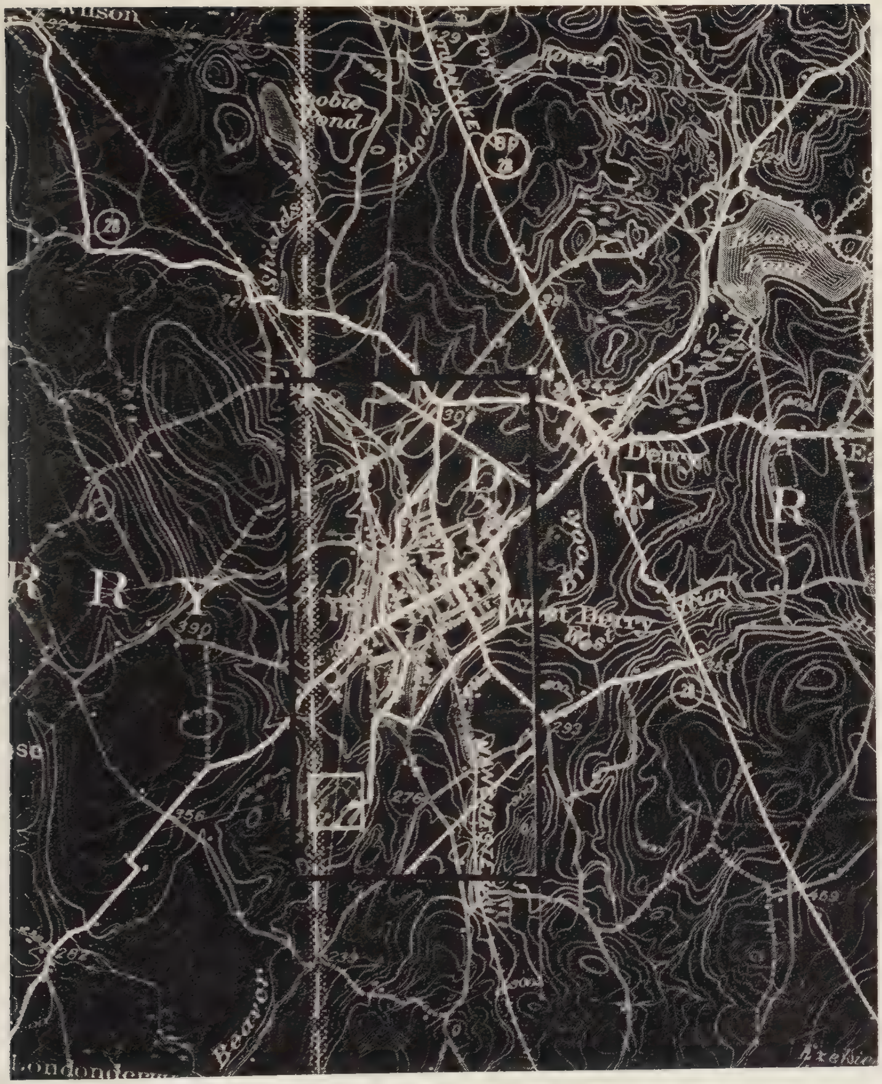
Wilson
Noble Pond
Shields
Brook
Derry
D E R R Y
R R Y
West Derry
Beaver Pond
Beaver
390
276
293
356
Londonderry

Fig. 1.

use an arbitrary coordinate system with a value of N 10,000, E 10,000 in the center of town at the intersection of the main street (Broadway) and the B & M R. R. Broadway and the railroad made an "X" intersection and it was along these that the main control traverses were run with closing sides to make two loops called the "A & B" traverses. The bearing system used was based on the R. R. baselines. The closures of the loops were of second order accuracy. The traverse points were of a semi-permanent nature, painted for future reference.

The cross-country trunk line surveys, which were originally random traverses, were tied into the aerial control lines to give a check on these and create additional loops with a minimum of work.

As soon as the traverses were run and checked out, the coordinates of the ground control points were calculated and noted on the 9″ × 9″ aerial contact prints. They were returned to Lockwood, Kessler and Bartlett, Inc. with these instructions:

(1) Provide working drawings only, at a scale of 1″ = 40′.

(2) Show streets, buildings, poles, large trees, travelled ways, ponds and brooks.

(3) Indicate any other planimetric data which may be helpful for determining property lines such as walls, fences and cultivated fields.

Briefly, the essence of photogrammetry is the creation of a measurable spatial model, the basic principle being similar to the manner in which our brains perceive a three dimensional scene with depth provided by superimposed images from our two eyes. In one method, light rays which originally went from the object (in this case, the ground surface) to the camera are reversed. The reversal of the light rays is done by pairs of projectors which are closer than were the original adjacent camera positions during flight and thus making a "model" which is smaller than the object. For planimetric data, the operator traces the desired details such as buildings, roads, and the outline of wooded areas. If contours were needed, the operator would follow a "floating point" over the model which had been preset with identifiable points of known elevation. As the operator moves over the model a plan is created by means of suitable linkage arms not unlike a pantograph.

While the aerial photographs were being processed through the plotting machines, the vertical control points were established on the ground. The U.S. Geological Survey provided bench mark information on the Seal Level Datum of 1929. Three bench marks were found to be useable, two along the B & M R. R. and the third at the town fire station on Broadway. Several level loops were made from these and the turning points and temporary bench marks were located, painted, and described to facilitate the profiling of each of the streets to be done later.

A field office was set up and a procedure was arranged for profiling each of the streets. Stations were marked off with a cloth tape from L to L of travelled ways. Using the pre-established T. P's, elevations were taken at 50 ft. intervals and at the sills of the buildings on each side of the street. This data was turned into the field office where it was checked and plotted on the photogrammetric work prints. The stationing on the ground and the scaling on the plans between streets checked out very well. Also added in colored pencil were underground utilities as observed in the field and as indicated by the various town departments.

All of this work was accomplished and turned over to Camp, Dresser and McKee in less than three months. The key point in this whole process, we believe, was that duplication of work was eliminated by following through with working plans from the outset to the final contract plans. This was accomplished by close cooperation between Lockwood, Kessler and Bartlett, Inc., Harry R. Feldman, Inc., and Camp, Dresser and McKee. It was found also that the aerial method provided at all times a "bird's eye view" of the project and the photogrammetric plans gave infinitely more details than would be economically feasible by ground surveys.

There remained only to obtain property owners and lines for easements and taking plans. Although, from our point of view, the assessors' records were incomplete, the town officials were extremely cooperative and helpful. The work involved with property lines will not be detailed here, but a few points will be mentioned. Here again the photogrammetric plans were exceedingly helpful in that they showed walls, fences and hedges which were excellent clues to the property lines. For the most part, it was a matter of going from door to door to obtain the owners' names and other information.

In this regard, it may be of interest to quote here verbatim a small portion of the report by one of the men working on this phase of the project. "Horne Brook Easement—Owners unknown—Land north of Maple Street, between the Derry Dressed Poultry Company's land, and that of the Derry Fibre Mills, Inc., including a gravel drive and a small wooden building. The abuttors believe that this parcel belongs to the Boston and Maine R.R. The Boston office of the B & M denies ownership. The Selectmen's Clerk believes that it is owned by the Derry Fibre Mills. There was no one around the small building, nor was there any identifying name on it. A January 1955 plan of the area, by a local surveyor, has the building labeled 'Marr Scaffolding Co.' This plan was made for land taking purposes for a proposed street, but the Selectmen dropped the project when a question over land ownership developed." Possibly, had the researcher scrutinized the little wooden building more closely he may have discovered a design cut in the door—a crescent shaped moon.

DISCUSSION

By Darrell A. Root,* *Member*

The results of the survey work performed by Harry R. Feldman, Inc. were turned over to us in the form of two sets of photogrammetric sheets. The work sheets covered the whole area in which sewers, interceptors, pumping station and treatment facilities were to be constructed. These sheets showed all the necessary topographical features, and in addition the surveyors had plotted the elevations of the centerline of the streets at every 50 ft, or at shorter intervals where necessary, the elevations of the sills of all the buildings, and the rim and invert elevations of all manholes, catch basins, and culverts. The underground utilities as observed in the field and the information furnished by town officials were also shown on the work sheets. We were furnished a set of aerial photographs which were used occasionally to check the photogrammetry, and in some cases used to check topography by the use of stereoscopic glasses.

Before the field surveying was undertaken, we advised the Surveyor that we would need detailed topographical surveys along the interceptor routes. This work was included with the base line survey work, and the details were placed on the photogrammetric work sheets. In addition to the street profiles, we required some profiles cross-lots which had been selected with the initial sewer layout. These profiles were taken at the time the street profiles were made. This information was also included on the photogrammetric work sheets.

Previous to the receipt of the photogrammetric work sheets, we had laid out a map of the proposed sewer system on a street map with the scale of 1″ = 400 ft. By using the photogrammetric work sheets, we first checked the locations of various sewer lines and the ends of the various sewer lines and corrected the proposed layout to agree with the details furnished on the work sheets. Construction plans on plan and profile sheets were then laid out to cover the proposed system, and these plans were started by tracing the plan information from the work sheets. Prints were made from the con-

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[*] Partner, Camp, Dresser and McKee, Boston, Mass.

struction drawings after the plan material had been completed, and these prints were then used as work sheets for designing the sewer system.

The first step in preparing the design work sheets was to plot the ground profile from the information on the photogrammetric work sheets. After the ground profile was plotted and the utilities shown on the profile, the size and location of the sewers was established and placed on the work sheets. At this time the information to be added to the plan was also included on each work sheet, such as the location of sewer line, manholes, and other information which was required to be added to the plan.

After a work sheet was completed, it was set aside until the work sheets that were tied into the sheet in question were completed. Such sheets covered upstream sewers, downstream sewers, and all lateral sewers which might come into any particular work sheet. All of the work sheets were then rechecked to ascertain that all the necessary and related changes were completed. The work sheet information was then transferred onto the construction drawing. This final construction drawing was the first time that a drawing, as such, had been prepared, because up to this time all the information was contained on either the photogrammetric work sheets or the sewer design work sheets.

During the development of the design sheets, it became apparent that minor changes were required in the overall layout. For example, a few lateral sewers were taken cross lots instead of around the block, and it was necessary to sewer a few additional streets. Because the photogrammetric work sheets contained information between the streets as well as along the streets, and because they showed all of the existing buildings, it was a simple matter to make adjustments in the sewer design work sheets because the information was available.

Before the preparation of the construction drawings was started, it had been decided that these plan and profile sheets would be reduced by half, so that the plans issued to the bidders for bidding purposes would be approximately 11″ x 18″. Considerable thought was given to the size, spacing of lettering, the weight of lines, and the presentation of material on the final drawing, so that when the sheet was reduced, we would have a legible, workable drawing on which contractors could base their bids. We also planned to use these same reduced drawings in the field for construction purposes.

A total of 93 plan and profile construction drawings, divided into two contracts, was prepared to cover the work on which bids were received. A total of 82,130 ft, or about 15.5 miles of intercepting and street sewers was laid out on these drawings. In addition to the sewers, these contracts called for the installation of 16,180 ft of house connections which were built within the street lines.

Low bid on the first contract was in the amount of $372,000, and low bid on the second contract was in the amount of $572,000.

We were particularly pleased with this method of developing the construction plans from the survey data furnished to us. The advantages to us were that the data was presented in a relatively short time from the date we authorized Harry Feldman, Inc. to proceed with this work, the photogrammetric work sheets contained more information than would have been developed from street surveys, we were furnished aerial photos of the area in which we were working, and that the cost of the survey work was reduced and we were able to pass this saving on to our client.

Mr. Chester C. Pease, Jr. was the Engineer in charge of the preparation of the construction plans on this project, and he is now Resident Engineer in charge of the construction. His principal assistant on both of these assignments is Manning S. Chellis.

BOSTON SOUTH BAY INCINERATOR — THE EVENTS LEADING TO ITS CONSTRUCTION

By John F. Flaherty,* *Member*

(Presented at a meeting of the Sanitary Section, B.S.C.E., held on December 3, 1958.)

Municipal incineration has been a long time coming to Boston, and has finally arrived with the construction of the South Bay Incinerator.

The problem of an adequate and sanitary method of refuse disposal for the City of Boston has been the subject of studies and reports extending back to 1908 and possibly earlier. In 1908, a special Commission appointed by Mayor Hibbard to investigate the collection and disposal of refuse, and a second Commission appointed in 1910, reported that the present methods of disposal were unsatisfactory and objectionable, and recommended that the City construct incinerators.

In 1922, George A. Johnson, a consulting engineer, made a study and submitted a comprehensive report on the problem to the Commissioner of Public Works, in which he stated that—

> "The dumps in which these materials, often heavily mixed with garbage due to poor separation, are now being deposited, are rapidly nearing their capacity in many cases. In from one to three years some of the largest dumps now in use will have to be abandoned, necessitating much longer hauls to new points of deposit, and consequently increased cost of collection and transport."

and further stated in his conclusions that—

> "The evidence at hand admits of no other conclusion than that the existing procedures involving refuse collection and disposal in Boston are unsanitary, inefficient, unduly costly, and as a whole unsatisfactory to the people.
>
> "There is but one wholly satisfactory method of refuse disposal, and that is its complete destruction by fire."

Commissioner of Public Works, George G. Hyland, engaged the services in 1941 of the engineering firm of Metcalf & Eddy to make a study and report on refuse disposal in the so-called 10-year Contract Area—comprising the older sections of Boston—and in 1950 retained the Thomas Worcester Company—another engineering organization—

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* Division Engineer, Sanitary Division, Boston Public Works Department.

to study and report on refuse disposal as it affected the entire City. Both engineering firms reported that the present practice of refuse disposal at open land dumps is unsanitary and a potential health menace and nuisance. Both recommended the construction of adequately designed incinerators as the best and only satisfactory solution to the refuse disposal problem.

Although the problem of refuse disposal has been under study for over fifty years, and all investigators have been unanimous in their recommendations that the City resort to incineration, we do not have one municipal incinerator operating in the City of Boston. There are several factors responsible for this delay, the chief ones being:

(1) The low cost of operating open land dumps (excepting the Spectacle Island operation) as compared with the high cost of constructing and operating incinerators.

(2) The continued availability of land dumping sites.

(3) The objections of residents and public officials to an incinerator being constructed within their district.

The first two factors have been discounted for most sections of the city due to the rapidly approaching exhaustion of land dumping sites. The opposition of citizens to the location of an incinerator anywhere in their district led to the selection of the South Bay section, an industrial area with unrestricted zoning, as the incinerator site, although it was known that subsoil conditions would result in a foundation problem.

In 1951, the firm of Metcalf & Eddy was engaged to submit a report on and to design the South Bay Incinerator. In their report, the engineers made the following recommendations:

1. The capacity of the plant should be 750 tons per day.

2. Mechanical stoking of the furnaces rather than hand-stoking should be provided.

3. The specifications should be so drawn as to permit competitive bidding by makers of chain-grate furnaces, Volund furnaces, and circular mechanically stoked furnaces.

4. Bids should first be received and the contract awarded for the purchase of the incinerator equipment. Thereafter, the building and other features of the plant should be designed and a separate contract awarded by competitive bidding.

5. No provision should be made for salvage of waste materials at the new incinerator.

6. Waste heat energy should be utilized by generating steam in the new incinerator. The steam should be transmitted to the City Hospital for use in that institution.

7. The burning of refuse in the incinerator should be confined to the five-day collection week. On Saturdays, Sundays and holidays when collections are not made, steam should be generated by burning oil under the new boilers in the incinerator.

8. The saving to the City in fuel and power bills by utilization of waste heat energy is estimated to be not less than $115,000 annually.

The selection of the South Bay area for location of the incinerator was influenced by the fact that it was zoned Unrestricted, was centrally located with respect to refuse hauling and was close enough to City facilities for effective waste heat utilization. Obtaining the plant site, however, was subject to several frustrating delays covering a period of over four years, from 1951 to 1955.

The first site selected was found to interfere with plans of the Massachusetts Market Authority for a wholesale meat market in this area. A second choice was objected to by the New Haven Railroad—which had taken over the market development from the Commonwealth—as it would be located in a proposed wholesale produce market area. A third site was selected on vacant land owned by the Commonwealth.

This latter site was under jurisdiction of the State Department of Public Works. Their plans for expressway construction in this area included using part of this land. When they had determined what land could be allotted to the City for an incinerator site, permissive legislation was filed in the General Court providing for the transfer of title to this land from the State to the City. Coincidentally, the City, in January 1955, made a taking of an adjacent parcel of 94,110 square feet from the New Haven Railroad.

Unfortunately, 1955 was an election year, the incinerator site became a political issue, and the bill was defeated. The City then made an additional taking from the New Haven Railroad in November, 1955 of 30,711 square feet, the only remaining land adjacent to the original taking and not owned by the State or needed for the expressway location. The total area of 124,821 square feet provides a compact but adequate site. To obtain additional space for equipment and materials during construction, a 100-foot wide strip adjacent to the site has been leased from the Commonwealth for a five-year period.

About the time these takings were made, a petition signed by the wholesale meat dealers and processors in the area, strenuously objecting to this location for the incinerator, was submitted to City officials. They stated that the incinerator would be detrimental to their business in spite of the fact that state and local health authorities had approved the incinerator site, and the local Federal Meat Inspection Bureau was not opposed to it. A few days after the petition was filed, I toured the market area and counted over twenty barrels with burning trash in front of the petitioners' establishments, all actively polluting the air.

There are several junk yards in the plant vicinity where extensive burning of automobile bodies is carried on, and which produces dense clouds of black smoke. Smoke emission is heavy at times from some industrial stacks in view of the site. We have taken pictures showing some of these occurrences. The State Department of Public Health has placed air sampling stations at various points to measure the amount of particulate matter in the atmosphere around the incinerator site. It will be interesting to see how these samplings compare with those taken after the incinerator is placed in operation.

All of the recommendations made by the engineers were accepted by the City, but, as the preliminary design proceeded, some changes were made. Failure of all the metropolitan communities, excepting Boston, to accept Chapter 559, Acts of 1952, which provided for the Metropolitan District Commission to construct and operate incinerators for the disposal of refuse from communities accepting the Act, and failure of the Boston City Council to approve a site in Dorchester for an M. D. C. Incinerator indicated the advisability of increasing the capacity of the South Bay Incinerator from 750 to 900 tons per twenty-four hours.

During the four years spent in acquiring a site, construction costs increased to a point where it was deemed advisable to take bids on furnishing four as well as six 150-ton per day furnaces. This was done in order to keep within the available appropriation by purchasing only four furnaces—if necessary—and constructing a building to house six furnaces, the other two furnaces to be installed at a later date when money became available.

Bids were opened on December 2, 1955 of proposals that could be made for furnishing four, five or six furnaces with combustion chambers, tubular waste heat boilers, fly-ash arrestors and other appurtenances, with four alternate types of mechanically stoked furnaces, namely; rectangular, circular, traveling grate and rotary kiln. No bid was submitted on a rotary kiln furnace. The traveling grate prices were high, and the award lay between the rectangular and circular grate furnaces, the low bids on both types being very close.

It was decided that, of the two, the rectangular furnace was better suited for the refuse burning and steam generating requirements at this plant, and, as the slight difference in price of $2,300 in a contract totaling $963,000 did not warrant an award based on price alone, the contract for four furnaces with Flynn & Emrich stoking grates was awarded to the George Allen Company. Exception to this award was made by one of the circular furnace bidders, who commenced litigation which delayed the final approval of this contract until May 28, 1956.

Additional appropriations were made for the incinerator, and two more furnaces were contracted for in April, 1957 at the price bid on December 2, 1955. The equipment contract was at this time assigned to the Tynan Incinerator Company.

The design of the building proceeded during the aforementioned litigation, and when it had advanced to a stage where the foundation could be designed, it was decided to award separate contracts for the pile foundation and for the refuse storage bin in order to have no delay in start of construction while awaiting completion of the detailed plans and specifications of the remainder of the plant.

Borings taken by the Raymond Concrete Pile Company in August and September of 1956 showed a very deep bed of soft blue clay between a top twenty-foot layer of loose fill and hard pan at a depth averaging 165 feet. One boring was driven 249 feet before encountering rock.

A contract for driving approximately 65,000 linear feet of concrete filled 12-inch steel piling was awarded the J. F. White Contracting Company. Work started in December, 1956 and finished in June, 1957. The contract for construction of a refuse storage bin was awarded the Coleman Brothers Corporation in April, 1957, and the work was completed in January of 1958. The John Bowen Company was low bidder on the building contract which was awarded in November, 1957, and this construction is still in progress.

Plans and specifications for construction of a 12-inch steam main from the incinerator to the Boston City Hospital are completed and invitations for bids on this work will be advertised soon. As part of this pipe line will be located under the Fitzgerald Expressway and Southeast Expressway interchange, construction will have to be co-ordinated with the highway work. In addition to furnishing all the steam requirements of the hospital, it is probable that the surplus steam will be sold to the Boston Edison Company under an agreement now being negotiated.

The total cost of construction will be approximately $5,500,000, comprising the following main items:

Engineering and Inspection	$ 275,500
Land (Estimated)	75,000
Pile Foundation	418,900
Refuse Storage Bin	412,600
Equipment—Furnaces and Appurtenances	1,456,000
Building and Site Work including Steam Main	2,855,000
Miscellaneous, including Borings, etc.	7,000
Total	$5,500,000

The annual operating cost, not including amortization, is estimated to be $560,000, the largest item being operating personnel at $367,000 yearly. Fuel oil for burning over week-ends and as supplementary fuel on days of peak hospital demand will cost approximately $113,000; electric power, $46,000; and maintenance $32,000 per year.

The South Bay Incinerator will dispose of the refuse produced in the older sections of the City, namely: South Boston, Charlestown, Roxbury and the City Proper, including the North End, West End, South End and the Back Bay. These districts have a combined area of thirteen square miles, approximately one-third of the City's area, and a population of 380,000, approximately fifty percent of that of the entire city.

When construction of the South Bay Incinerator was recommended in 1951, the adoption of this method of disposal in place of the present method indicated a saving to the City of approximately $357,000 per year. Since that time, the reduction of $199,000 per year in the disposal contract price and the increase in construction and operating costs show no appreciable savings to the City by incineration.

The following table shows that the sum of the present cost of refuse disposal and the cost of generating steam at the hospital equals approximately the net cost of incineration including the cost of amortization and taking credit for income from private dumping and sale of surplus steam.

COMPARISON OF REFUSE DISPOSAL COSTS—PRESENT METHOD VS. INCINERATION

PRESENT DISPOSAL COSTS	
Scow and Dump Contract	$372,000
Labor at Wharf Station	30,000
Rental of Dump Site	24,000
	$426,000
Generating Steam at Hospital	
Fuel Oil	$245,000
Labor	83,000
Maintenance	30,000
	$358,000
Total Yearly Cost with Present Disposal Method	$784,000

ESTIMATED COST WITH INCINERATION	
Incineration Amortization	$358,000
Operation and Maintenance	560,000
	$918,000
Generating Steam at Hospital	0
Income at Incinerator	
Dumping Privilege	$ 75,000
Sale of Surplus Steam	60,000
	$135,000
Total Yearly Cost with Incineration	$783,000

Neither economics nor sanitation was the determining factor in adopting incineration for refuse disposal. The prime factor was the rapidly approaching exhaustion of refuse dump sites in the City. Neighboring communities, with one exception, do not have adequate capacity in their disposal sites for Boston's refuse. The relatively small remaining capacity at dumping sites in Boston must be reserved for incinerator residue. However, the increase in opposition to open land dumps and the tendency to legislate restrictions on them eventually may have forced Boston—if the incinerator was not built—to resort to all disposal on the Boston Harbor islands, at a cost considerably greater than incineration.

As stated in the beginning, municipal incineration has been a long time coming to Boston. However, the administrative officials of the City believe that once the leaders and members of civic organizations have an opportunity to inspect and observe a modern incinerator in operation, much of their former opposition to this facility will decrease, and we shall be able to obtain funds and sites for the additional incinerators needed to eliminate entirely the nuisance of land dumps in the City of Boston.

BOSTON SOUTH BAY INCINERATOR — DESIGN AND CONSTRUCTION

By Harrison P. Eddy, Jr.,* *Member*

(Presented at a meeting of the Sanitary Section, B.S.C.E., held on December 3, 1958.)

Mr. Flaherty has described the difficulties of obtaining any site upon which this plant could be constructed. The one finally secured is about as tight a site as could possibly be used. Examination of old maps indicated that this was at one time water front property, in fact it may have been completely under water before the construction of the docks at the south end of South Bay.

In addition to having limited space around the plant, the site required expensive foundations.

GENERAL DESCRIPTION OF PLANT

The purpose of the plant is to burn mixed municipal refuse, consisting of garbage and rubbish. There are six furnaces, each of a rated capacity of 150 tons per day and three waste heat boilers, each of a capacity of 75,000 lbs. of steam per hour. Each waste heat boiler is served by two furnaces.

The building is approximately 241 feet long by 200 feet wide and there are three large chimneys.

The collection vehicles enter the building at the east end passing over truck scales at the entrance. They back against the curb and discharge their contents into the receiving bin. From the bin, refuse is hoisted by grab bucket cranes to the charging hoppers on the top floor, then falls by gravity onto the grates in the furnaces on the stoking floor. After combustion the ashes are dropped into ash pits below the furnaces whence, after quenching, they are discharged by gravity into trucks and hauled away from the plant and dumped.

The flow of gases from the furnaces and combustion chambers normally passes through waste heat boilers, fly ash arrestors, and induced draft fans into the chimneys. Bypass flues are provided from each furnace to bypass the boilers when they require cleaning or are not required for steam production. When the bypass flues are in use

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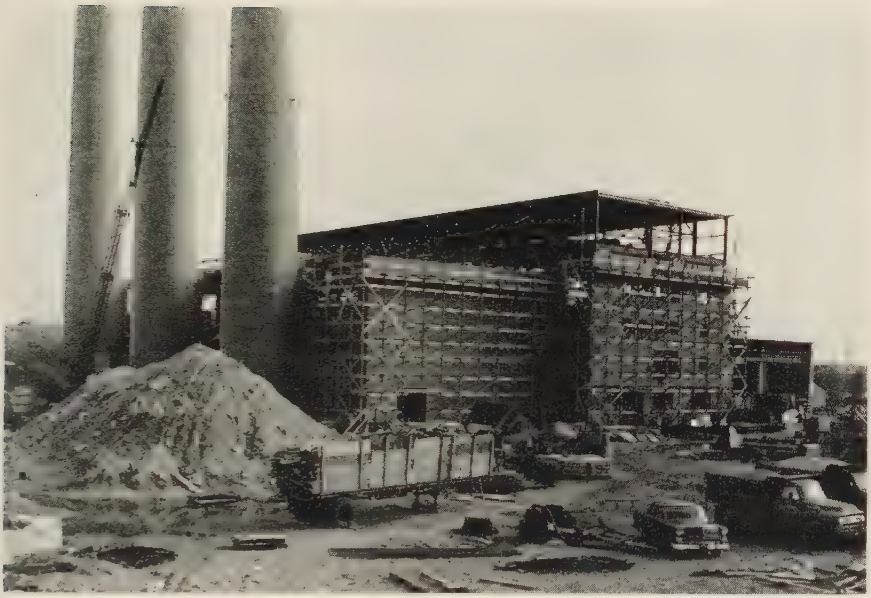
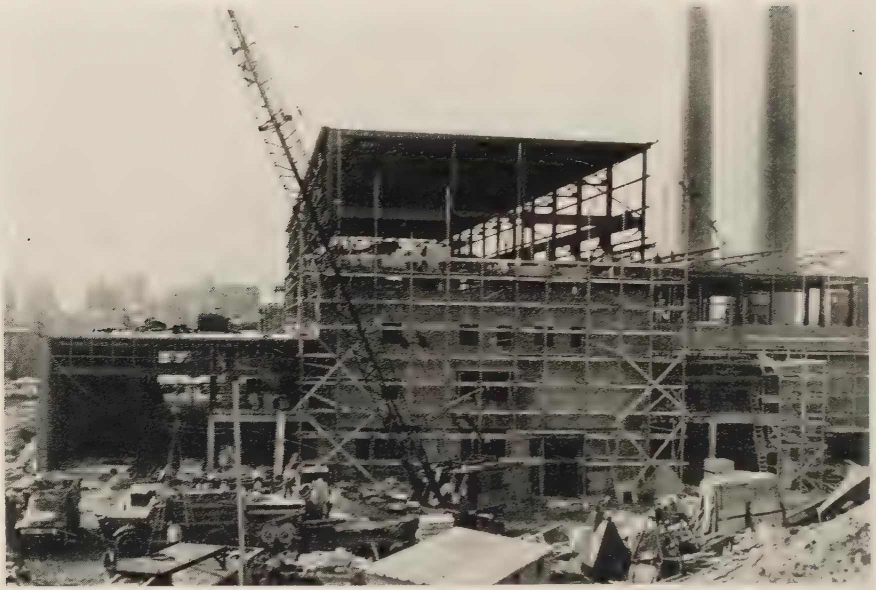


South Bay Incinerator Looking Southeasterly.

the gases may be cooled in a spray chamber before entering the fly ash arrestors and the induced draft fans, or may flow directly to the chimneys, bypassing boilers, fly ash arrestors and I.D. fans. The fly ash arrestors and I.D. fans were manufactured by the Fly Ash Arrestor Corp. and are the dry multiclone type. From the induced draft fans the gases go directly to the chimneys, one chimney being provided for each pair of furnaces. The chimneys are 22 feet in outside diameter at the base and have complete self-supported refractory linings to the top.

The boilers were manufactured by Babcock & Wilcox. They are three-drum, single pass, water tube, waste heat boilers and are equipped with the usual superheaters, soot blowers, and other auxiliaries. In addition, each boiler has auxiliary oil burners to permit steam generation at periods when the refuse furnaces are not in operation. These boilers will generate steam at 250 lbs. per square inch gage.

The steam will be used primarily at the large City Hospital nearby. As Mr. Flaherty has pointed out, a connection will probably be made with the Boston Edison steam system. If this is done, sur-



South Bay Incinerator—Boston City Hospital in Left Center Background.

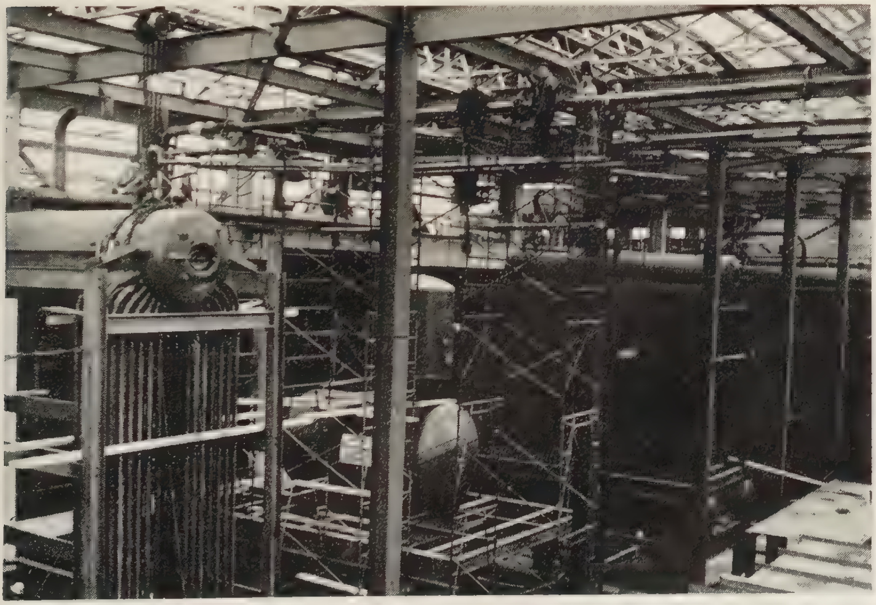
plus steam from the incinerator would become available for use in the Edison system. A small amount of steam will be used for certain auxiliaries in the incinerator building.

The cranes, of which there are three in number, span the entire width of the bin and charging floor, a total of 67 feet. An end crane can be parked at either end of the room if out of order, at which time the other two cranes can serve all the furnaces.

Charging of the furnaces is controlled by means of hydraulically operated charging gates with water cooled throats located at the bottom of the charging hoppers. The grates are operated hydraulically and are inclined at an angle of approximately 15 degrees from the horizontal. As burning proceeds, the fuel bed is moved forward to the front of the furnace by the upward tilting of alternate sections of the grate. This grate action is controlled by the fireman as the condition of the fire warrants. After the refuse has been thoroughly burned and reaches the front of the furnace, the ash remaining is dropped through a hinged section of the grate into the ash pit below. The refuse for each furnace enters through three charging gates, one for each cell, and falls onto the high end of the stoker grates at the back of the furnace.

There are three ash pits, one for each cell of the furnace. They are closed on the bottom by water-sealed horizontal sliding gates. The ashes are quenched in the ash pits and then dropped through the gates into a dump truck on the floor below.

The furnace and boiler contract was awarded to George Allen & Son Inc. and subsequently was assigned to the Tynan Incinerator Co. Although at the time the contract was signed by the City, sufficient funds were available for only four furnaces and two boilers, subsequent allocations made it possible to extend this contract to include all six furnaces and three boilers, thus providing for the complete plant a furnace capacity of 900 tons of refuse per 24 hour day, with steam generating capacity of 225,000 pounds per hour. The furnaces are designed around the Flynn & Emrich Co. inclined rocker grate stokers. Furnace walls are of the gravity type consisting of first quality refractories with a carborundum brick facing extending 4 ft. above the grate to withstand abrasion and spalling of the furnace walls. Nosings around the charging opening are also of carborundum brick shapes. Arches over the furnaces, combustion chambers and



South Bay Incinerator Boiler Room—Showing Erection of 3 Drum Tubular Waste Heat Boilers—Capacity 75,000 lb. per hr. Each.

South Bay Incinerator, Stoking Floor, Installing Refractories in Rectangular Furnaces With Flynn & Emrich Stokers.

flues are of the Detrick Co.'s American Design flat suspended arches. All walls outside of the furnace chamber are of the insulated unit or sectionally supported walls. Floors which are in contact with hot gases are insulated and air cooled.

For use during periods when refuse may be received with considerable moisture content or a relative high volume of noncombustible material, oil burners have been installed in the furnace chambers to aid in burning the refuse or to maintain proper temperatures for deodorizing the gases. Forced draft fans, one for each furnace, are also provided to aid combustion or to increase steam production when their use may be required. Air for the forced draft fans is drawn from outside the building and blown directly into the furnaces without preheating.

A complete system of controls is provided to record temperatures, drafts and other pertinent information which will be recorded on instrument panels on the operating floor. Part of the control system is the provision for automatically controlled water sprays in the bypass flues to reduce the gas temperature to a degree to permit the gases to enter safely the fly ash collectors and I. D. fans when they are not being chilled by the boilers. In the boiler room sufficient steam driven auxiliary equipment has been provided so that steam generation can be accomplished in case of power failure.

FOUNDATIONS

Borings indicated a deep layer of soft blue clay underlying several layers of fill, silt, peat, fine sand and clay, with compact material and hardpan beginning approximately 113 to 150 feet below the surface. Rock was encountered at a depth of 243 feet at one point. After thorough consideration of various types of construction, it was decided that end bearing pile foundations should be used to support the heavy loads of this building, the chimneys and other equipment.

Because of the steel shortage which was prevalent at that time, contractors were using great ingenuity in the use of used material. Accordingly, bids were invited for driving piles of various types and the bidders were given the option to bid on any number of types which they chose as well as on new and used material. Bids were received in October 1956. The lowest was for driving H piles but the delivery of the steel would have resulted in a delay of seven to eight months before starting driving. Therefore, the next higher bid, for driving second-hand concrete-filled steel pipe piles, was accepted. The pipe used was 12¾ in. o.d. oil country line pipe weighing approximately 50 pounds per lineal foot. This pipe looked as if it had been used in acid Louisiana marshes because one side of it, perhaps the invert, apparently had been almost continuously riddled with corrosion but when delivered to the site it had been so thoroughly patched by welding that it was considered acceptable for use. In accordance with the Engineering News Record formula, these piles driven to a resistance of 22 blows per inch with a Vulcan No. 1 hammer will carry a safe working load of 70 tons. A pile carrying 70 tons and filled with 4,000 pound concrete will have stresses in the steel of 6,700 psi. and in the concrete 670 psi. which are above the Boston Building Code limits of 6,000 psi. and 400 psi., respectively. Also, the borings indicated that the required resistance would not be met until a depth of between 150 and 180 ft. had been reached. This violates the slenderness provision of the Boston Building Code which requires that the load be reduced when the depth to diameter ratio exceeds 40. An appeal was made, however, on the grounds that there had been in the past, no known failure of such a pile due to buckling, and the stresses were within reason and permitted by other codes. This appeal was granted.

A pile loading test was made in November 1956, with two adjacent piles for use as tension or anchor piles. The first section of the test pile was 98 feet in length and no driving was necessary for the first 18 feet as the weight of the pipe and hammer caused the pile to penetrate to that depth. Moderate resistance was encountered for the next 10 to 14 ft. and then little resistance as it entered the deep layer of soft blue clay until the 96 ft. depth was reached where driving was stopped to permit splicing of the upper section. When driving was resumed, little resistance was encountered to the 160 ft. depth where the resistance increased rapidly until 26 blows were recorded for the last inch of penetration at a final depth of 163.4 ft. below cut-off elevation. The loading test was conducted in accordance with the building code, applying the load in five ton increments every four hours, the final load of 140 tons remaining on the pile for a 48-hour period. The maximum settlement recorded was 0.372 inches which was well within the limit of .500 inches allowable. With successful conclusion of tests the pile driving was commenced immediately.

During the driving, careful observations were made in each pile as to its deflection from the vertical by means of dropping a light down the pipe. In granting the appeal the Boston Building Department had stipulated that after driving, the pile should not be out of plumb more than 2 ft. for the upper 100 ft. and the remainder of the pile should not be out of plumb more than 2 percent of the remainder of its length. It was soon obvious that with piles of the length that were being driven, this specification was not being met in a number of cases. We were fortunate at this time that Dr. Bjerrum, the head of the Norwegian Geotechnical Institute, was serving as a visiting professor at M.I.T. Dr. Bjerrum had made extensive studies concerning the driving of piles in soft material and the lateral support that could be expected from such soil. Dr. Bjerrum recommended and the Building Dept. agreed that piles be acceptable if the radius of curvature for the upper 75 ft. were not less than 1,400 ft. and for the lower portion not less than 1,000 ft. This criterion is based on a maximum allowable stress in the pile of 15,000 psi. resulting from the initial curvature and the load imposed by the superstructure. The use of this criterion has to be tempered to some extent by the nature of the loads which are carried and the consideration of the number of piles which share the load.

In order to determine the curvature of the piles, an inclinometer was devised. This instrument consisted of a frame with wheels that fit snugly inside the pile. Within the frame there was inserted a three-tube manometer connected to a common stop cock which was located at the lower end of the instrument. A nylon fish line was attached to the handle of the stop cock, so that it could be closed by a jerk at the surface of the ground. The inclinometer was lowered into the pile with the stop cock open. At a predetermined depth, the stop cock was closed and the instrument raised. By reading the difference in the level of liquid in the manometer tubes, the slope and direction of slope at the desired level was obtained. Of the 566 piles driven, it was found necessary to use this instrument on approximately 140. Of this number, 30 piles were rejected as unsatisfactory. Seven additional piles were rejected for various other reasons, including indications that the pile had cracked during driving. The worst deviation noticed was approximately 25 ft. from the top of the pile to the horizontal projection of the estimated location of the tip. In another instance, a deviation of 33 degrees was observed within a vertical distance of 10 ft.

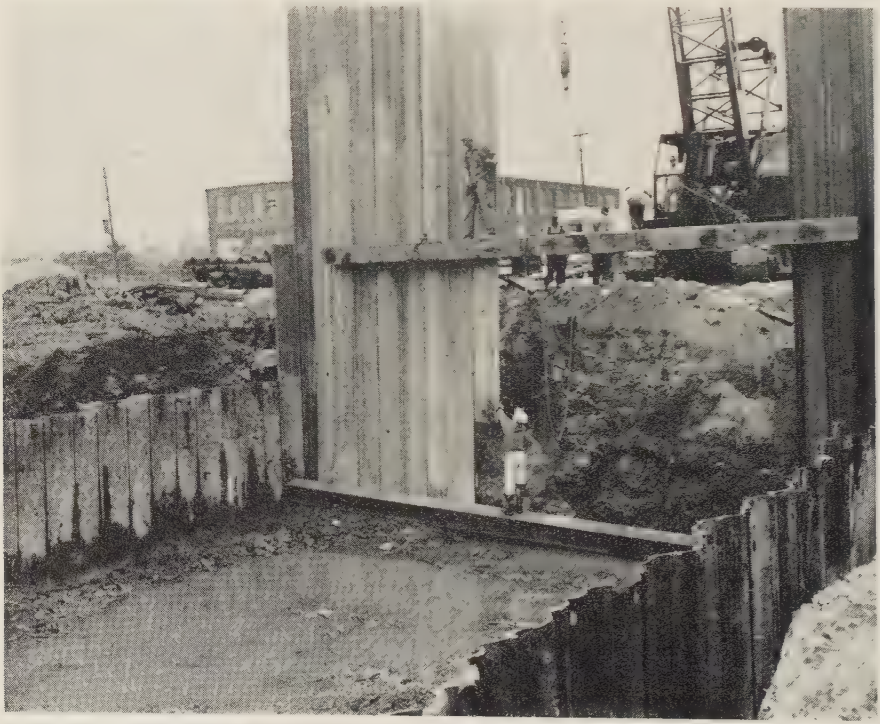
CORROSION SURVEY

A study was carried out to determine the amount of corrosion of the steel pipe that could be expected. This study was made by the Electro Rustproofing Corporation of New Jersey and included an analysis of the galvanic action due to the differences in the various layers of soil and a survey of stray currents in the area due to the proximity of the New Haven Railroad yards. The results of their investigations indicated that the pipe piles would suffer minor galvanic attack in the blue clay area adjacent to the sand and gravel. In addition, minor corrosion would also take place in the fill due to the presence of cinders and other deleterious materials. It was estimated that based on surface potential gradients, a single pile would lose approximately 540 pounds of steel over a 50-year period due to stray currents. Considering all factors involved, it is estimated that without protection the steel pipe piles will have a useful life well in excess of 50 years. In order to minimize the effects of the small amount of corrosion expected, design provided for keeping the piles insulated from one another and to ensure that they would not be used for grounding purposes or come in direct contact with any electrical current.

RECEIVING BIN

In order to provide storage for the refuse which will be collected during a day shift and burned throughout the 24 hours, a large storage bin was provided. It is 200 ft. long by 24 ft. wide and the length of the row of six furnaces. The bin had to be below ground because the site was so small that ramps could not be provided for an above-ground bin and dumping floor.

The excavation for the bin was approximately 210 ft. long by 35 ft. wide and 30 ft. deep below the ground surface. Observations made during pile driving indicated that the water table remained fairly constant at 6 ft. below the ground surface which meant a depth of excavation of approximately 24 ft. below the ground water level.



South Bay Incinerator Refuse Bin Coffer Dam.

Consideration was given to two methods of construction of the bin without using piles. One of these involved building it as an open tank or barge and launching it into a dredged channel and then sinking it into position, with the weight of the building helping to overcome flotation. Another method was to build the bin in place within close sheeting, placing a heavy floor of tremie concrete sufficiently thick to overcome buoyancy. In either of these two methods the rest of the building would have been carried on pile foundations and there would have been hinged joints to permit differential movement of the bin due to loading and unloading. It was finally decided to use pile foundations like those of the building with the bin tied into the piles to overcome flotation. As added protection, the bin was filled with water after its completion and prior to construction of the building to help resist buoyancy. The walls were designed to resist hydrostatic lateral pressure by cantilevering from the bottom slab. The base slab was waterproofed by means of brick in mastic plus a 2-ply membrane. The sidewalls were waterproofed by means of a 5-ply membrane seal covered by a poured concrete protecting cover.

The 66-ft. high bin wall in the direction of travel of the loaded bucket is completely armored with steel plate welded to I beams placed in the concrete wall, because with high speed crane operation the crane will bump into it and slide up the face of the wall so much of the time that otherwise disintegration of the concrete would probably be rapid.

A contract for construction of the bin was awarded to Coleman Bros. in May 1957. Steel sheeting for the cofferdam was driven approximately 3 ft. outside the line of the bin walls to about 35 ft. below the ground surface. Excavation inside the cofferdam was then carried on by clam shell bucket. At first water was pumped from inside the cofferdam at sumps at either end of the excavation. As excavation proceeded, however, the steel sheeting tended to move in and a system of well points was installed. The well points were pumped from July until the project was completed the following January.

TENNESSEE VALLEY AUTHORITY: INTERNATIONAL EXPERIMENT

By Benjamin W. West

Among the changes of a very fundamental character in the economic life of the United States of America which were ushered in by the administration of the late President Franklin D. Roosevelt, perhaps none have been so controversial and few more far reaching in influence than has the Tennessee Valley Authority which was originally established by Act of the U. S. Congress, in 1933 for the development of the power and navigation potentials of the Tennessee River as well as to further certain other economic phases of the great fertile valley which constitutes the watershed of that stream.

By virtue of certain basic U. S. National laws, the central government has jurisdiction over all navigable streams in the United States and this power is administered, in the main, by the Corps of Engineers of the United States Army. It was that agency which constructed the Wilson Dam near Florence, Alabama at the foot of a rapids in the Tennessee River known as "Muscle Shoals" within a few years after the signing of the Armistice in 1918—that structure having previously been authorized as a World War One measure, but it soon became apparent that such a structure could not be completed in time for it to make any contribution to victory in that struggle, so the work was held in abeyance until hostilities had ended. Even before the Wilson Dam was completed, a long and heated controversy ensued in the U. S. Congress and elsewhere in the political and industrial life of the United States over the question of whether the power plant and the war-time-constructed nitrate plants would be operated for fertilizer production by the U. S. Government (as actually required by the original National Defense Act of 1916 which had authorized the construction of the great dam) or by some private organization. This debate continued over a period of approximately 12 years until the F. D. Roosevelt Administration came into power in Washington in March, 1933. Mr. Roosevelt took almost immediate steps to bring about some adjustment which would embrace not only the war industries and Wilson Dam at Muscle Shoals, but would encompass a comprehensive development of the natural resources of the region, including harnessing the river for navigation, flood control, generation of electric power, and other purposes; use of the chemical facilities for research and development to improve fertilizers and make them available as economically as possible, widespread tests and demonstrations of fertilizers, encouraging reforestation and other activities to improve forest and agricultural land use, and further the agricultural and industrial development of the region.

One of Mr. Roosevelt's chief motives in proposing the establishment of the Tennessee Valley Authority was to set up what he termed a "Yard Stick" which would, so he suggested, serve as a guide in determining if the rates charged by electric power companies in the United States were in fact, too high as some had charged. Among the critics of the electric power industry in the United States (and, incidentally, a great exponent of the Hydro-electric Power Commission of Ontario who had previously sought to bring about the establishment of a "Muscle Shoals Commission"), was the late U. S. Senator George W. Norris of Nebraska. He fought what was for several years known in the United States as the "Ford Offer for Muscle Shoals" which resulted when the late Secretary of War John W. Weeks advertised the World War One Muscle Shoals Industries, including the then incomplete Wilson Dam, for sale in 1921. Mr. Henry Ford came forward with an offer which precipitated one of the longest and most heated controversies in the history of governmental operations in the United States and ended only in 1933 with the establishment of the Tennessee Valley Authority. Senator Norris, prior to 1933, had introduced several bills for the public operation of the Muscle Shoals properties and two of them, one in 1928 and one in 1930, were passed by the Congress, but were vetoed by Presidents Coolidge and Hoover, respectively. The depression and the election of President Roosevelt created a climate in which the TVA Act could be passed with the President's support. Therefore, after Mr. Norris had supported Governor Roosevelt in the election of 1932 and when the latter proposed the Tennessee Valley Authority, he had the very enthusiastic and able support of Mr. Norris and many of the latter's colleagues so that the measure became law in the early part of the Roosevelt Administration.

However, almost from the very beginning of its existence, the TVA, as it has become widely known, has been dogged by the opposition of those who champion the private financing and operation of electric power enterprises. Some of these controversies have been decided only in the courts—in two instances, these cases having gone to the United States Supreme Court. In one such case, the late Mr. Wendell Wilkie, Presidential candidate in 1940, was seriously involved on the side of the electric power companies concerned. During the Eisenhower Administration, there have been grave differences of opinions with regard to over-all policies as may be illustrated by the so-called "Dixon-Yates" contract (now abandoned) which would have authorized the construction of a large power plant near the west bank of the Mississippi River at West Memphis, Arkansas. Under the plan, the Atomic Energy Commission would have purchased the power from the plant and delivered it to TVA as an off-set to some of the power delivered by TVA to the Atomic Energy Commission plant at Paducah, Kentucky.

Under specific authorization by the U. S. Congress, the Corps of Engineers conducted what was, up to that time, perhaps the most thorough and exhaustive scientific study of the Tennessee River basin that had ever been made of any river system. This study was started in 1922 and was completed in 1929 at a cost of approximately $1,000,000 and dealt with navigation, flood control and electric power development. A complete coordinated scheme of navigation and water-power development comprising 149 separate hydro-electric projects within the basin was worked out and presented in the detailed report with corresponding suggested designs, and approximate cost estimates.

This report proved to be a valued contribution to the rapid advances made by the TVA in the early stages of its development. An outstanding example of the helpfulness of this report may be cited in the case of what was suggested as the "Cove Creek Dam," but which, in reality, has been named "Norris Dam" in honor of the late U. S. Senator George W. Norris. Almost immediately upon the establishment of the main TVA offices at Knoxville, Tennessee, in the early part of 1933, work was started on the then proposed "Cove Creek Dam" and this was pushed to completion by 1936 to become one of the most spectacular engineering projects of the TVA and to form one of the greatest artificial lakes in the U. S. A. up to that time. The project was inaugurated with much "fanfare" and with numerous people of National prominence in the United States participating in the ceremonies.

The Tennessee River is the largest tributary of the Ohio, which in turn empties into the Mississippi. It is formed by the confluence of the Holston and the French Broad rivers at Knoxville, has a length of 652 miles, and a drainage area of 40,900 square miles. At times its discharge exceeds that of the Ohio, into which it flows. After flowing southwest through east Tennessee into Alabama, it flows westerly across north Alabama, touches a corner of Mississippi, and flows almost due north through Tennessee and Kentucky to its junction with the Ohio. Its source is 800 feet above sea level and it discharges into the Ohio at 302 feet above sea level. The main river is subject to wide fluctuations in flow with a minimum recorded discharge at Florence, Alabama (Wilson Dam) of 4,300 cfs and a maximum at the same point of 481,000 cfs. The average recorded flow at Florence is given as 53,300 cfs.

Statistically speaking, it would require much more space than can be devoted to this subject to really do the TVA justice, but perhaps a brief summary of its outstanding accomplishments and activities over the last 24 years may be justified. Thus, to this end the following is quoted from a recently-published report by the TVA: "TVA has harnessed the Tennessee River and its tributaries with a system of multiple-purpose dams to extract the maximum control and usefulness from flowing water. Floods have been regulated, a new waterway opened to commerce, water supplies for cities and industries improved, recreation opportunities afforded, fish and wildlife conservation advanced, and health conditions improved by the virtual elimination of malaria. Electric power has been generated economically in both hydro and fuel plants. It has been distributed widely and at low cost and used for the fuller and better balanced development of the resources of the region. It has also contributed greatly to the national defense. Chemical research and experimental production of fertilizers for use in widespread agricultural programs have provided a basis for improved farm management and land use, in the nation as well as the Valley region. Planting of seedlings, protection of timberlands against fire and other hazards, and better management have been encouraged to reestablish the beauty and economic value of the region's forests. Improved farm and forest management has brought better control of water on the land, curbing erosion, conserving moisture for plant growth, and slowing the runoff into the streams.

"Progress in these accomplishments in the Tennessee Valley region has been the work of many people, institutions, and agencies. The work of TVA in controlling the river, producing power and new chemical fertilizers, and in other activities has opened new opportunities for people of the region to make better use of their natural resources. Widespread cooperation with other agencies, as authorized and directed in the TVA Act, has helped build up and reinforce state and local units, private enterprise, and individuals in exercising increasing responsibility and initiative in resource development.

"The TVA flood control program was proven to be justified by virtue of its effects on major Tennessee River floods in 1946, 1947 and 1950 when it reduced by 10 to 12½ feet the crests of the fifth, sixth, and seventh largest floods of record on that stream; thus saving property owners along its course millions of dollars in damage. In 1950 TVA's 2-foot reduction of the Mississippi crest at Cairo, Illinois, spelled the difference that saved 200 square miles of farm land in the Birds Point-New Madrid floodway from evacuation and flooding.

"Traffic on the new waterway doubled in five years. Grain traffic from the Midwest increased. Specially designed barges began regular transportation of automobiles. Navigation became a strong inducement to industrial development. During World War II, even before the new navigation channel was completed, it was plied by tows stacked with military jeeps, trucks, and ambulances. Ocean-going ships were constructed on its banks at Decatur, Alabama, and dispatched down-river to the Gulf.

"In the electric power field, by the year 1956, TVA engineers and builders had brought to near completion the extraordinary 6-year program which added 6 million kilowatts of generating capacity to the TVA power system. During the year they placed in operation 1,469,500 kilowatts of generating capacity, only a little less than the record of 1,734,300 kilowatts completed the year before. The total installed capacity had been increased from 2,993,610 kilowatts at the end of fiscal year 1950 to 9,279,485 kilowatts at the end of fiscal 1956.

"The year included the completion and placement in operation of what is believed to be the 'world's largest' steam-electric power plant (in point of installed capacity of 1,600,000 kilowatts in nine units) at Kingston, Tennessee. This plant is a major source of power for the U. S. Atomic energy defense plants at nearby Oak Ridge, Tennessee and its great condensers use as much water in reducing the exhaust steam from the huge turbine to water as the city of New York consumes for various purposes. Its mammoth boilers consume a 50 ton carload of coal every six minutes when the plant is in full operation.

"The year 1956 also brought a new record in power generation of

57.5 billion kilowatt-hours, and a new record of sales to the U. S. Atomic Energy Commission. The Oak Ridge and Paducah plants, which together use from TVA more than twice as much power as is consumed in the city of New York, took 30.2 billion kilowatt-hours—56% of TVA's total sales."

Shortly after the late Dr. Albert Einstein wrote a letter to President F. D. Roosevelt in which he drew attention to energetic efforts by Germany to bring into being atomic weapons and urged him to undertake serious investigation in this field, a mysterious project of enormous proportions was under construction at Oak Ridge, Tennessee. This plant, which produced essential materials for the experimental bombs tested at Almagardo, New Mexico and used against enemy territory for the first time at Hiroshima and Nagasaki, Japan demanded about 300,000 kilowatts of installed power capacity in 1950. However, by 1956, this figure had climbed to 3½ million kilowatts. When World War II ended and the original mystery of the Oak Ridge operations was unveiled, it was revealed that one of the major reasons for locating the atomic plant in the Tennessee River Valley was because of the availability of large blocks of electric power in that area. Between 1950 and 1956, the atomic energy plants multiplied their demands for TVA electric power elevenfold so that they used 31 billion kilowatt hours in 1956, which was well over half of TVA's total output and was almost twice the amount of electric energy used in New York City that year.

More and more frequently, TVA is being requested to supply consultants on foreign TVA-like projects around the globe. TVA engineers and other experts familiar with its development programs are being sought for responsible positions on foreign river valley developments. Visitors from all over the world come to TVA in increasing numbers to study its operation and its development programs and to inspect its various projects. Since World War II, TVA has had over 12,000 visitors from 90 countries; in 1954 alone there were some 1800 from 70 countries. Noted world travelers are pointing out that TVA is coming to be recognized around the world as a symbol of resource development, pointing the way to a higher living standard and more satisfying way of life. As an outstandingly successful test-demonstration of multipurpose river valley resource development, TVA has become an example for the world and is being emulated on increasing numbers of the earth's river valleys.

HARVEY BANKS KINNISON

HARVEY BANKS KINNISON

1890 - 1959

Harvey Banks Kinnison was born in Hopkins, Missouri, July 21, 1890. He spent the early years of his life in the West. He attended the University of Idaho, obtaining his B.S. in Civil Engineering in 1914. In 1916 he married Anita Taylor in Eugene, Oregon. Mr. Kinnison died on March 14, 1959. He leaves his wife; two sons, Hallard Banks, and Philip Taylor; and one daughter, Mrs. Edward Jones.

He started his engineering work as District County Engineer of Bonner County, Idaho. Later he was chief of party for the Colony Holding Corporation, Atascadero, California. In 1918 he joined the United States Geological Survey, which he served for the rest of his life. He was located first in Texas, then in Kansas, then in Massachusetts, where he became District Engineer in 1926. He served as District Engineer for the Boston District until November, 1956, when he was transferred to California, where he was Branch Area Chief for the western states with headquarters in Menlo Park, California. With this appointment he became one of the four branch chiefs of the Water Resources Division of the Geological Survey in the country, having charge of its activities in the Western States, Alaska, and the Hawaiian Islands.

As District Engineer of the Boston District, Mr. Kinnison made a very marked contribution to the whole subject of hydrology in New England. Very soon after he was appointed, the 1927 Vermont flood occurred. This was the first of the large, recent floods in the northeastern United States and as such was one of the floods that led to the whole system of flood control in New England. It also was the start of modern analysis of the hydrology of floods. His Water Supply Paper on the New England flood of November, 1927, was an extremely careful and valuable analysis of this flood and was first of this kind of flood paper published by the Geological Survey.

Mr. Kinnison's work in the Geological Survey's office in Boston extended over a period of 30 years, during which time the department grew from a small office employing a few people to its present size with a total personnel of 24.

Aside from the various publications of the Survey, Mr. Kinnison also wrote many papers on stream flow hydrology covering both drought and flood conditions, descriptions of the various floods, and analyses of flood formulae. These were published in the Boston Society's Journals during the period from 1930 to 1948. His paper on "Stream Flow Data, Its Collection and Use," published in 1931, was awarded the Desmond-Fitzgerald medal.

His greatest contribution to the science of flood hydrology was a paper which he wrote assisted by B. R. Colby entitled "Flood Formulas Based on Drainage Basin Characteristics," published in the Transactions of the American Society of Civil Engineers in 1945. This was an analysis of floods in New England rivers resulting in a classification of floods of various frequencies based on the flood characteristics of their drainage area based on topographic features. Since the publication of this system of analysis, it has been widely used in New England in determining floods for the design of dams, bridges, and culverts. It was the first of flood analyses which gave a method of using the physical data of a river for its flood-producing characteristics.

Mr. Kinnison joined the Boston Society of Civil Engineers in 1926, served as a director 1947-49, vice president 1945-47, and was president in 1947-48. He served as a member of the Committee on Floods, beginning with the one after the 1927 flood. He was a member of the John R. Freeman Fund Committee. He was also a member of the American Society of Civil Engineers, the American Geophysical Union, and the New England Water Works Association.

Until he left for California, he made his home in Melrose, where he was active in various community affairs such as the Y.M.C.A. and the Boy Scouts, and particularly for five years in the construction of the new Melrose Highlands Congregational Church.

From his work with the Geological Survey, Mr. Kinnison was, of course, widely known by hydraulics engineers throughout all New England. No one who had contact with him could fail to be impressed by his great ability in his special line of work, and even more than that, by his willingness to give help in the way of information in any situation, even beyond the requirements of his office. Those who had dealings with him know how clear and direct was his attitude on all engineering problems so that one was always sure of his interested cooperation in any case where his help was requested, and such assistance was always given with an authority and an experienced judgment that made it all the more valuable. His was a great contribution to the theory and practice of hydrology in New England.

OF GENERAL INTEREST

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETING

Boston Society of Civil Engineers

APRIL 15, 1959.—A Joint Meeting of the Mass. Section of the A.S.C.E. with the Boston Society of Civil Engineers was held this date at the Hotel Lenox, Boston, Mass., President Ernest A. Dockstader of the Mass. Section of A.S.C.E. presiding.

After dinner President Dockstader called the meeting to order at 7:30 P.M., and after introducing the head table guests, turned the meeting over to President Edward C. Keane of the BSCE to conduct any necessary business.

President Keane requested the Secretary of BSCE to present a recommendation of the Board of Government to the Society for action. The President stated that this matter was before the Society in accordance with the provisions of the By-Laws and notice of such action published in the ESNE Journal dated April 13, 1959.

The Secretary presented the following recommendation of the Board of Government to the Society for initial action to be taken at this meeting.

MOTION "to recommend to the Society that a Publication Fund, for publishing Sanitary Lecture Series on Waste Water Treatment, be established by a loan of a sum not to exceed $3000 from the Principal of the Permanent Fund; also that a fund be established by a loan of a sum not to exceed $2500 from the Principal of the Permanent Fund for republishing Vol. 1 of Contributions to Soil Mechanics." Proceeds from sale of publications to be used to repay the loans.

On motion duly made and seconded it was VOTED "that the Board of Government be authorized to transfer an amount not to exceed $3000 from the Principal of the Permanent Fund for publication of Sanitary Lecture Series on Waste Water Treatment and also transfer an amount not to exceed $2500 from the Principal of the Permanent Fund for republishing Vol. 1 of Contributions to Soil Mechanics, and that the proceeds from sale of publications to be used to repay the loans."

President Keane stated that final action on this matter would be taken at the May 20, 1959 meeting of the Society.

The Secretary also announced the names of applicants for membership in the BSCE and that the following had been elected to membership on April 6, 1959:—

Grade of Member—Donald Ball, James P. Collins, Andrew P. Fisichelli,* William L. Fletcher, Karl H. Kinder, Robert C. Libbey, Bradford Saivetz, Alden K. Sibley.

Grade of Junior—Cosmo D. Capobianco,** Dominic F. Frangioso, Jr.,** Neal B. Mitchell, Jr.

---

* Transfer from Junior.

** Transfer from Student.

President Keane then turned the meeting back to President Ernest A. Dockstader of the ASCE who introduced the guest speaker, Mr. W. Dean Devereux, Technical Advisor, Olin Mathieson Chemical Corporation who presented an interesting talk on "The Fairchild Aluminum Bridge." The talk was illustrated.

A brief discussion followed, with adjournment called at 9:15 P.M.

40 members and guests attended the dinner and 53 attended the meeting following the dinner.

ROBERT W. MOIR, *Secretary*

MAY 20, 1959.—A Joint Meeting of the Boston Society of Civil Engineers and the Structural Section, BSCE was held this evening at the United Community Services Building, 14 Somerset Street, Boston, Mass., and was called to order at 7:00 P.M., by President Edward C. Keane.

President Keane stated that the minutes of the previous meeting held April 15, 1959 would be published in a forthcoming issue of the JOURNAL and that the reading of those minutes would be waived unless there was objection.

President Keane announced the death of the following members:—

> Harvey B. Kinnison, who was elected a member May 9, 1928 and who died March 14, 1959.
>
> Wilbur W. Davis, who was elected a member December 19, 1906 and who died April 15, 1959.
>
> Daniel M. Moore, who was elected a member October 17, 1928 and who died April 14, 1959.

The Secretary announced the names of applicants for membership in the Society and that the following had been elected to membership on May 18, 1959:—

> *Grade of Member*—Edwin F. Coffin, Jr., William F. Swift.
>
> *Grade of Associate Member*—William J. Collins.*

President Keane requested the Secretary to present a recommendation of the Board of Government to the Society for action. The President stated that this matter was before the Society in accordance with the provisions of the By-Laws and notice of such action had been published in the ESNE Journal dated May 4, 1959.

Secretary presented the following recommendation:—

MOTION "to recommend to the Society that a Publication Fund, for publishing Sanitary Lecture Series on Waste Water Treatment, be established by a loan of a sum not to exceed $3000 from the Principal of the Permanent Fund; also that a fund be established by a loan of a sum not to exceed $2500 from the Principal of the Permanent Fund for republishing Vol. 1 of Contributions to Soil Mechanics." Proceeds from sale of publications to be used to repay the loans.

On motion duly made and seconded it was VOTED "to approve above recommendation of the Board of Government.

President Keane stated that this was the final action on this matter.

President Keane stated that this was a joint meeting with the BSCE Structural Section and called upon William A. Henderson, Chairman of that Section to conduct any necessary business of the section at this time.

President Keane introduced the speakers of the evening, Mr. George R. Rich, Director and Mr. Wilfred M. Hall, President of Chas. T. Main, Inc., who gave a most interesting talk which was illustrated with slides on "The Engineering and Design Features" and "General and Construction Phases" of the Niagara Power Project.

The meeting was preceded by a

---

* Transfer from Junior.

dinner and 54 members and guests attended the dinner. 113 members and guests attended the meeting.

The meeting adjourned at 9:00 P.M.

Robert W. Moir, *Secretary*

SANITARY SECTION

March 4, 1959.—The meeting was called to order at 7:00 P.M., by Chairman Clair N. Sawyer after an informal dinner at the Smorgasbord on Province Street. Eighty-eight members and guests attended the meeting and thirty attended the dinner.

The annual report of the Executive Committee was read by the Clerk of the Section.

The report of the Nominating Committee was read by Mr. Ariel A. Thomas, and the following people were submitted for consideration as officers and executive committee members for the coming year;

Chairman	Prof. Harold A. Thomas, Jr.
V-Chairman	George M. Reece
Clerk	Robert H. Culver
Executive Committee	James L. Dallas
	George W. Hankinson
	Charles Y. Hitchcock, Jr.

The report of the Nominating Committee was accepted, the nominations were closed, and it was VOTED that the Clerk cast one ballot for the nominees presented. This was done.

The elected officers and members of the executive committee were introduced by the Chairman. The Chairman also expressed his appreciation for having been given the privilege of serving as Chairman of the Section.

It was requested that members contact the officers of the section regarding their opinion of the Smorgasbord as a place for the informal dinner.

The Chairman announced that approval had been given by the Board of Government for publication of the seminar lectures on sewage treatment; also that the annual outing would be held this year at the Wood's Hole Oceanographic Institute on June 6.

The speaker of the evening was Paul E. Langdon of Greeley & Hansen, Chicago, Illinois, who presented an illustrated paper on the Deer Island Sewage Treatment Works. The speaker gave a lucid description of the treatment works and the problems encountered in the design of these works. The paper was followed by a lengthy discussion concerning many aspects of the design.

The meeting was adjourned at 8:45 P.M.

George M. Reece, *Clerk*

TRANSPORTATION SECTION

April 22, 1959.—A meeting of the Transportation Section was held in the Harvard Room of Purcell's Restaurant.

The 41 guests enjoyed the evening, starting with a preliminary warm-up informal meeting from six to seven p.m. followed by the Dinner and speaking.

Ephraim A. Brest, Chairman of the Massachusetts Port Authority, was the principal speaker.

Mr. Brest abandoned his prepared address to substitute an informal talk on his recent visit to the West Coast where he attended an International Air Conference and visited several of the airports.

He stated that he was confident the jet-age for passenger transportation service was now here and that progress in this field is rapidly increasing.

William A. Fisher, *Clerk*

SURVEYING AND MAPPING SECTION

April 1, 1959.—The thirty-ninth meeting of the Surveying and Mapping Section was held at the Society Rooms at 7:00 P.M.

The meeting was called to order by Mr. Nelson Gay, Chairman of the Section. The minutes of the January 28, 1959 meeting were read and accepted.

The Chairman then introduced Mr. Edward Mullaney of the Corps of Engineers who spoke on Hydrographic Surveys. Several methods, hand soundings and electronic soundings and locations were discussed and sketches showing results were illustrated by slides.

Upon completion of his discussion, a question and answer period was held and the meeting then adjourned at 8:45 o'clock P.M.

There were 28 members and guests present.

RUDOLF S. SLAYTER, *Clerk*

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